MONTHLY NOTICES

OF THE

ROYAL ASTRONOMICAL SOCIETY.

VOL. LI. MARCH 13, 1891. No. 5

Lieut.-General J. F. TENNANT, R.E., C.I.E., F.R.S., President, in the Chair.

Thomas Richard Clapham, Austwick Hall, Clapham, Lancaster; and
Arthur Kennedy, 1 Clement's Inn, W.C.; and Ashtead, near Epsom, Surrey,

were balloted for and duly elected Fellows of the Society.

The following candidates were proposed for election as Fellows of the Society, the names of the proposers from personal knowledge being appended:—

Alfred Henry Fison, D.Sc., Assistant Professor of Physics, University College, London (proposed by F. W. Levander);
Thomas Gordon, F.R.Met.Soc., Ironmonger, 9 Scotch Street, Whitehaven (proposed by Sir R. S. Ball);
George E. Hale, B.Sc., 4545 Drexel Boulevard, Chicago, U.S.A. (proposed by S. W. Burnham).

One hundred and nine presents were announced as having been received since the last meeting, including among others:—

S. Newcomb, Discussion of Observations of the Transits of *Venus*, 1761 and 1769, and G. W. Hill, New Theory of *Jupiter* and *Saturn*, presented by the American *Nautical Almanac* Office; Catalog der Astronomischen Gesellschaft, zone $+65°$ bis $+70°$ (Christiania), presented by the Society; E. Weiss, Katalog der Argelander'schen Zonen, $-15°$ bis $-31°$, presented by Professor

Weiss; J. E. Gore, Catalogue of Binary Stars for which Orbits have been Computed, presented by the Author; Madras Observatory, Meridian Observations made in the years 1868–70, presented by the Observatory; W. T. Lynn, Celestial Motions, 7th edition, presented by the Author; Royal Observatory, Edinburgh, Catalogue of the Crawford Library, presented by the Observatory; L. Becker, The Solar Spectrum at Medium and Low Altitudes, presented by the Author; O. Callandreau, Étude sur la théorie des Comètes périodiques, presented by the Author; R. Wolf, Handbuch der Astronomie, Band I., Theil II., presented by the Author; 17 original negatives of *Jupiter*, made with the 36-inch Equatoreal of the Lick Observatory, presented by Professor Holden; Comparative Photographs of High and Low Sun Spectra, presented by Mr. F. McClean; Stand for Lantern at evening meetings, presented by Mr. W. Schooling; Oxygen bottle, presented by Mr. E. Ristori.

Notes on the Preparations for the Work of the Astrophotographic Chart at the Royal Observatory, Greenwich.

(*Communicated by the Astronomer Royal.*)

I. *The Catalogue of Guiding Stars.*

The resolutions of the Permanent Committee relating to guiding stars are as follows:—

11. On prendra comme étoile-guide une belle étoile du champ, dont la position soit connue à 5″ près.

12. Une Commission de cinq membres (MM. Bakhuyzen, Christie, Gill, Kapteyn, Lœwy) est nommée dans le but:

1. De déterminer les positions des centres de toutes les plaques pour l'équinoxe de 1900.

2. De choisir les étoiles-guides et d'assurer leur réduction.

The positions of the centres of the plates decided on by this Commission were published in the fifth number of the *Bulletin* in a paper by W. H. M. Christie. The centres are all at whole minutes of R.A. and whole degrees of declination for the equinox of 1900. The distances in R.A. between centres in the same zone vary from 8 minutes at the Equator to 3 hours at declination +89°; and the centres are so arranged that no star is more than 63′ from the centre of some plate.

As regards the second part of the resolution, the work of selecting guiding stars has been divided amongst the observa-

tories which expressed their willingness to undertake it as follows :—

Observatory.	Zone in Decl.	Observatory.	Zone in Decl.
Greenwich ...	+90° to +60°	Leiden	−6° to −9°
Pulkowa	+59 „ +37	Melbourne ...	−10 „ −14
Leiden	+36 „ +30	Cape of Good Hope	−15 „ −23
Greenwich ...	+29 „ +25	Groningen ...	−24 „ −40
Paris	+24 „ + 8	Cape of Good Hope	−41 „ −51
Algiers	+ 7 „ − 2	Sydney	−52 „ −64
Greenwich ...	− 3 „ − 5	Melbourne ...	−65 „ −90

Mr. Hollis has been engaged for some time on the zones allotted to Greenwich, and the work is well advanced.

Professor Bakhuyzen proposed the following rules for selecting these stars, suggested by his experience in a preliminary examination of certain portions of the sky :—

1. Generally the brightest star within a circle of 22′ radius from the centre of the plate was to be chosen.

2. If, however, this star was fainter than 9·0 mag., the nearest star to the centre of 9·0 mag. or brighter was to be added as a supplementary guiding star.

Mr. Hollis originally selected stars for the zones +60° to +80° according to these rules, but as he found rather a large proportion of faint stars, the effect of extending the radius of the circle to 30′ was examined. The numbers of stars of different magnitudes found in the two cases are compared in the following table :—

Number of Guiding Stars within limiting circle of

Magnitude.	22′ radius.	30′ radius.
9·5	90	28
9·1 − 9·4	155	64
8·6 − 9·0	291	211
8·1 − 8·5	295	242
7·6 − 8·0	178	242
7·1 − 7·5	126	212
6·6 − 7·0	129	191
6·1 − 6·5	58	92
5·6 − 6·0	43	63
5·1 − 5·5	14	24
Brighter than 5·1	13	23

The numbers of additional stars required in accordance with the second rule were 277 and 133 in the two cases respectively.

It is to be noted that the co-ordinates of the guiding stars relatively to the centre of the plate are to be measured in the plane of the plate, which is a tangent plane to the sphere, and that corrections will be required to the differences of R.A. and declination between the star and the centre of the plate to convert them into these rectangular co-ordinates in order that the centre of the plate may be set as accurately as practicable to the defined position.

II. *Errors of Réseau.*

The resolutions of the Permanent Committee relative to the réseau are as follows:—

6. Les traits des réseaux auront 130^{mm} de longueur, leur distance sera de 5^{mm}. Le nom de l'observatoire sera inscrit sur le réseau.

15. Le réseau sera impressionné sur chaque plaque par de la lumière parallèle, dans un châssis placé devant l'objectif photographique lui-même, au foyer duquel on aura placé une source de lumière.

16. On fera usage d'un réseau pour la construction de la Carte.

17. Le réseau, pour la Carte, sera le même que pour le Catalogue.

Two very beautiful silver-on-glass réseaux have been received from Dr. Vogel, the plates being 160^{mm} square, and lines of 130^{mm} in length being ruled with a fine point on the silver (so as to leave clear glass) at intervals of 5^{mm}. Arrangements have been made for impressing these on the plate strictly in accordance with resolution 15. A circular metal plate is fitted to the dew-cap of the photographic telescope by four screws. In the centre of the plate is an aperture 140^{mm} square, opposite which the réseau and plate are to be placed. They are brought into this position in a dark-slide, 8½ inches square, the réseau being held in the dark-slide by four thin plates of silver ($\frac{1}{50}$ inch thick) placed at the corners, which separate the silver film by a very small distance from the sensitive surface of the plate to be impressed.

The corresponding ground edges of the réseau and of the plate bear against three agate planes placed similarly to those determining the position of the plate in the telescope when photographing stars—viz., two agates bearing on the ground edge of the réseau marked A (which is the standard edge for orientation) at 142^{mm} apart, and one bearing on the middle of the ground edge marked B.

At the focus of the object-glass is placed a small electric lamp of about $1\frac{1}{3}$ candle-power (6 volts and 0·8 ampère) excited by a secondary battery of four small storage cells, all other light being of course excluded. With this arrangement, which gives a pencil of parallel rays for imprinting the réseau, it is found that an exposure of thirty seconds gives a good image of the réseau on the plate.

With some of the réseaux Dr. Vogel has supplied a table of their errors. This was not done for the Greenwich réseaux, and the errors have been examined at Greenwich. The investigation is not yet complete, but the following results have been obtained:—

(*a*) The lines are sensibly straight and parallel, or at least are parallel and sensibly similar curves. This seems to have been assumed by Dr. Vogel in the lists of errors he has issued, for he has only given one number applying to the whole line of 130^{mm} in length. At Greenwich the lines parallel to the side B on a photographic copy of one of the réseaux were compared at nearly every 5^{mm} of their length by means of a micrometer (constructed for measuring photographs of the Transit of *Venus*, 1874), with a glass millimetre scale. The distances between them were found to remain constant within the limits of accidental error. The consideration of $16 \times 27 = 432$ residuals shows the limits of possible error. These residuals are grouped as follows:—

	No. of Residuals.
Greater than 0″·50	0
0″·50 to 0·40	2
0·40 to 0·30	9
0·30 to 0·20	40
0·20 to 0·10	140
0·10 to 0·00	241

(*β*) The errors of the above lines from a uniform scale are very small, and have the following values, if the errors of the millimetre scale, carefully determined at the time the Transit of *Venus* photographs were being measured in 1877, are still valid.

Réseau line.	Error shown by Comparison with Scale.	Correction to Scale.	Error of Réseau.
	mm.	mm.	mm.
A 1	−0·0222	+0·0120	−0·0102
A 2	−0·0157	0·0121	−0·0036
A 3	−0·0061	0·0073	+0·0012
A 4	−0·0037	0·0096	+0·0059
A 5	−0·0035	0·0116	+0·0081
A 6	+0·0002	0·0105	+0·0107
A 7	+0·0006	0·0106	+0·0112
A 8	+0·0076	0·0047	+0·0123
A 9	+0·0051	0·0066	+0·0117
A 10	+0·0031	0·0082	+0·0113
A 11	−0·0002	0·0095	+0·0093
A 12	−0·0033	0·0146	+0·0113
A 13	+0·0002	0·0137	+0·0139
A 14	−0·0016	0·0114	+0·0098
A 15	+0·0035	0·0108	+0·0143
A 16	+0·0041	0·0108	+0·0149
A 17	+0·0035	0·0079	+0·0114
A 18	+0·0063	0·0101	+0·0164
A 19	+0·0088	0·0052	+0·0140
A 20	+0·0063	0·0093	+0·0156
A 21	−0·0110	0·0234	+0·0124
A 22	−0·0129	0·0268	+0·0139
A 23	−0·0090	0·0254	+0·0164
A 24	+0·0116	0·0031	+0·0147
A 25	+0·0110	0·0036	+0·0146
A 26	+0·0131	0·0041	+0·0172
A 27	+0·0031	0·0129	+0·0160

It is to be remarked that these errors are those of a copy, and the falling off at A 1—5 is possibly not the same on the original, but the effect of some photographic accident. The matter is still under investigation.

III. *Course of the Work, Weather, &c.*

It may be interesting to give a few notes of what has been accomplished since regular work was undertaken at the commencement of February. During the thirty-two days from February 9 to March 12, at least two observers have been on the alert from soon after sunset till midnight or later, on all days except three. Fifteen of these nights were completely cloudy; three were partially cloudy, as shown by a small number

of meridian observations; and eleven were available in some degree for photography, though several were more or less foggy. On these nights twenty-one plates have been exposed either for star-trails (for adjustment, &c.) or for regular photographs, representing a total duration of actual exposure of $12^h\ 49^m$. Better results will, doubtless, be obtained as the work becomes more familiar.

IV. *Star Photographs.*

In respect of the taking of actual photographs, attention must be paid to the following resolutions of the Permanent Committee :—

8. Chacun des directeurs d'observatoires aura la liberté de commander ses plaques à tel fabricant qu'il voudra choisir.

18. On adoptera, pour le temps de pose devant donner les étoiles de grandeur 11·0 le produit par 6·25 du temps de pose nécessaire pour obtenir la grandeur 9·0 de l'échelle d'Argelander.

19. Chaque observateur devra s'attacher à obtenir sur ses clichés destinés au Catalogue la grandeur 11·0, déterminée aussi exactement que possible au moyen de l'échelle d'Argelander que l'on prolongera au-delà de la grandeur 9·0 par l'emploi du coefficient 2·5.

A chacun sera laissé le soin d'apprécier si ses clichés contiennent les étoiles dont la grandeur atteint cette limite.

23. Il sera fait, pour chaque cliché du Catalogue, deux poses successives, la seconde ayant une durée d'un quart de celle de la première et de telle sorte que la distance des deux images soit de 2 à 3 dixièmes de millimètre.

Le Comité recommande aux observateurs de déplacer l'instrument *en déclinaison* pour effectuer la seconde pose, si leur instrument leur permet de la faire, c'est-à-dire s'il est muni d'un micromètre.

With respect to resolution 8 it may be stated that the following plates have been tried: Paget, Cramer, Seed, Star, Mawson and Swan. Our thanks are due to the various makers for the trouble they have taken in cutting plates to the required size and in grinding edges. The selection of the best plate for the work has been a matter of considerable difficulty where the merits are so nearly equal, but after some experience a slight preference is felt for the "Star" plates, if ferrous oxalate development be used.

The most important information with respect to resolution 19 has been derived from two plates taken on 1891 March 4 at $8^h\ 6^m$ $+66°$ (one of the adopted centres in the region assigned to Greenwich), the first with an exposure of 30 min., and the second with two exposures of 6 min. and $1\frac{1}{2}$ min. respectively. The northern halves of these two plates were carefully examined, and the diameters of the stars measured. All Argelander's stars in this region were clearly shown with the $1\frac{1}{2}$ min. exposure with the exception of one, D.M. $+ 67°{\cdot}519$, which is

shown by the longer exposures to be photographically much fainter than D.M. + 67° ·520 close by. Further, the comparison of the diameters with Argelander's magnitudes gives the following approximate empirical formula connecting diameter in seconds of arc (d), magnitude (m), and time of exposure in minutes (t) :—

$$m = 13{\cdot}80 + 2{\cdot}5 \log t - 8{\cdot}3 \log d.$$

This is not advanced as a final result with full physical significance, but only as a convenient formula, sufficiently true within the limits selected for the work. In deducing it, it was assumed that to produce an image of given diameter, m and t are connected by the relation

$$m = \mathrm{C} + 2{\cdot}5 \log t.$$

It will be seen that this is tacitly assumed in the resolutions of the Permanent Committee, and means that (1) increasing the intensity of the source of light is exactly equivalent to increasing the time of exposure in the same proportion, and (2) the magnitude-ratio is the number whose logarithm is 0·4. The quantity C is a function of the diameter, and it was assumed that the diameter increases as some power of the time of exposure. From a comparison of the 30 min. and 6 min. exposures this power was found to be 1/3·46, and from a comparison of the 30 min. and 1 min. exposures, 1/3·17. The value 1/3·3 was adopted in the formula, which thus becomes—

$$m = \mathrm{C}' + 2{\cdot}5 \log t - 8{\cdot}3 \log d.$$

Finally, the values of C′, as deduced from the stars available, are as follows :—

Star D.M.	Mag. Arg.	C′ 30 min.	C′ 6 min.	C′ 1½ min.
66°541	6·5	13·51	14·04	14·47
67·538	7·0	13·35	14·51	14·86
66·538	7·8	13·41	13·93	13·93
66·539	8·3	13·59	13·46	13·51
66·548	8·5	14·62	15·12	15·69
66·536	8·8	13·39	13·42	13·53
66·549	8·8	13·99	13·31	12·67
67·520	9·0	14·49	14·85	14·36
66·543	9·1	12·77	12·32	12·49
67·524	9·4	13·91	14·36	14·61
66·546	9·4	14·08	13·91	14·05
66·534	9·5	13·78	14·36	13·67
67·521	9·5	14·23	14·36	13·97
67·523	9·5	13·78	13·88	13·02
67·527	9·5	12·61	13·05	12·22
66·547	9·5	14·16	13·20	13·67
		13·73	13·88	13·80

The value C′=13·80 was thus adopted in the general formula.

From this formula we can deduce the times necessary to obtain stars of a given magnitude on a night actinically similar to 1891 March 4. Mr. Criswick describes this night as "only moderately good, and better at the time of the short exposures than during the long exposure," which accords with the small value of C′ deduced from the long exposure. The night was, however, probably a fair sample of the observing weather which will be available at Greenwich, and the following table will be thus approximately correct:—

Times of Exposure requisite to obtain Discs of given Diameter from Stars of given Magnitude.

Diam. of Disc.	Magnitude.		
	14·0	11·0	9·0
	min.	min.	sec.
6″·0	461	29	277
5·0	252	16	151
4·0	120	7·6	72
3·0	46	2·9	28
2·5	25	1·6	15
2·0	12	0·8	7

It is doubtful whether the formula can be extended much below discs of 3″; the minimum disc visible is something less than 3″ in diameter. A faint photographic disturbance can often be seen with no measurable disc when the place of a star is known from a longer exposure; but for the Chart plates, if the 14th magnitude stars are to be readily discernible, they should probably have a diameter of about 2″·5, and the plates should thus be exposed for about 25^{m} or 30^{m}.

By resolutions 19 and 23 the exposures for the Catalogue plates would thus be 2^{m} and 30^{s}, but in order to facilitate the work of measurement it may be advisable to give rather longer exposures, say 4^{m} and 1^{m}.

The following table shows the diameters of discs of bright stars with exposures of 30^{m}, 2^{m}, and 30^{s} respectively:—

	Magnitude.							
	1	2	3	4	5	6	7	8
min.	″	″	″	″	″	″	″	″
30	97	73	56	42	32	24	18	14
2	43	33	25	19	14	11	8	6
sec.								
30	28	21	16	12	9	7	5	4

These exposures must, of course, be prolonged on bad nights. It is proposed to mount an auxiliary photo-telescope with 4-inch object-glass by Dallmeyer, pointing to *Polaris* or λ *Ursæ Minoris*,

so that during the long exposure of the plate for the star-chart, a test-plate from the same batch of plates may be taken with a series of short exposures on *Polaris* and rapidly developed (say for 1^m with the standard developer) as an indication of the actinic character of the atmosphere, and as a guide to the exposure necessary to give stars to the 14th magnitude on the Chart plates. From preliminary experiments which have been made, it has been found that a faint image of *Polaris* is obtained with an exposure of 2^s with the Dallmeyer 4-inch telescope.

Variations of Latitude deduced from the Observations of Polaris made at Greenwich, 1851–1889. By Professor H. G. van de Sande Bakhuyzen, Foreign Associate.

The accordance existing between the variations of the latitude deduced from observations made in Berlin, Potsdam, and Prague in the years 1889 and 1890 (*Astron. Nachr.* vol. cxxvi. p. 145) is so evident that it is not possible to explain them by accidental errors. One of the most probable systematic errors which might have caused those variations is an inequality of the refraction at equal distances north and south from the zenith, produced either by an anomalous refraction in the observing-room, or by a configuration of the strata of uniform density in the atmosphere, which is not symmetrical north and south of the zenith.

From an investigation of Professor Albrecht and one of my own, it seems, however, that that error cannot be admitted.

Professor Albrecht has shown that from October 1889 to February 1890 the results of the observations of stars at zenith distances from $2^\circ\ 38'$ to $10^\circ\ 32'$ are the same as those from observations of stars whose zenith distances are comprised between $12^\circ\ 46'$ and $26^\circ\ 29'$ (*Astron. Nachr.* vol. cxxvi. p. 158).

By the courtesy of Professor Helmert, I have received the daily results for the latitude given by each pair of stars observed in Berlin, Potsdam, and Prague from January 1889 to April 1890, so that I could calculate for that whole period the latitudes from observations of stars very near to the zenith. I have employed for that purpose twenty-four stars, whose zenith distances, with the exception of two, are smaller than 5° (the mean zenith distance was $2^\circ\ 53'$). Reducing these observations in the same way as has been followed by Professor Albrecht in the reduction of all the observations, I obtained for the mean monthly results the following values. In the third column I have added the results of the observations of all the stars.

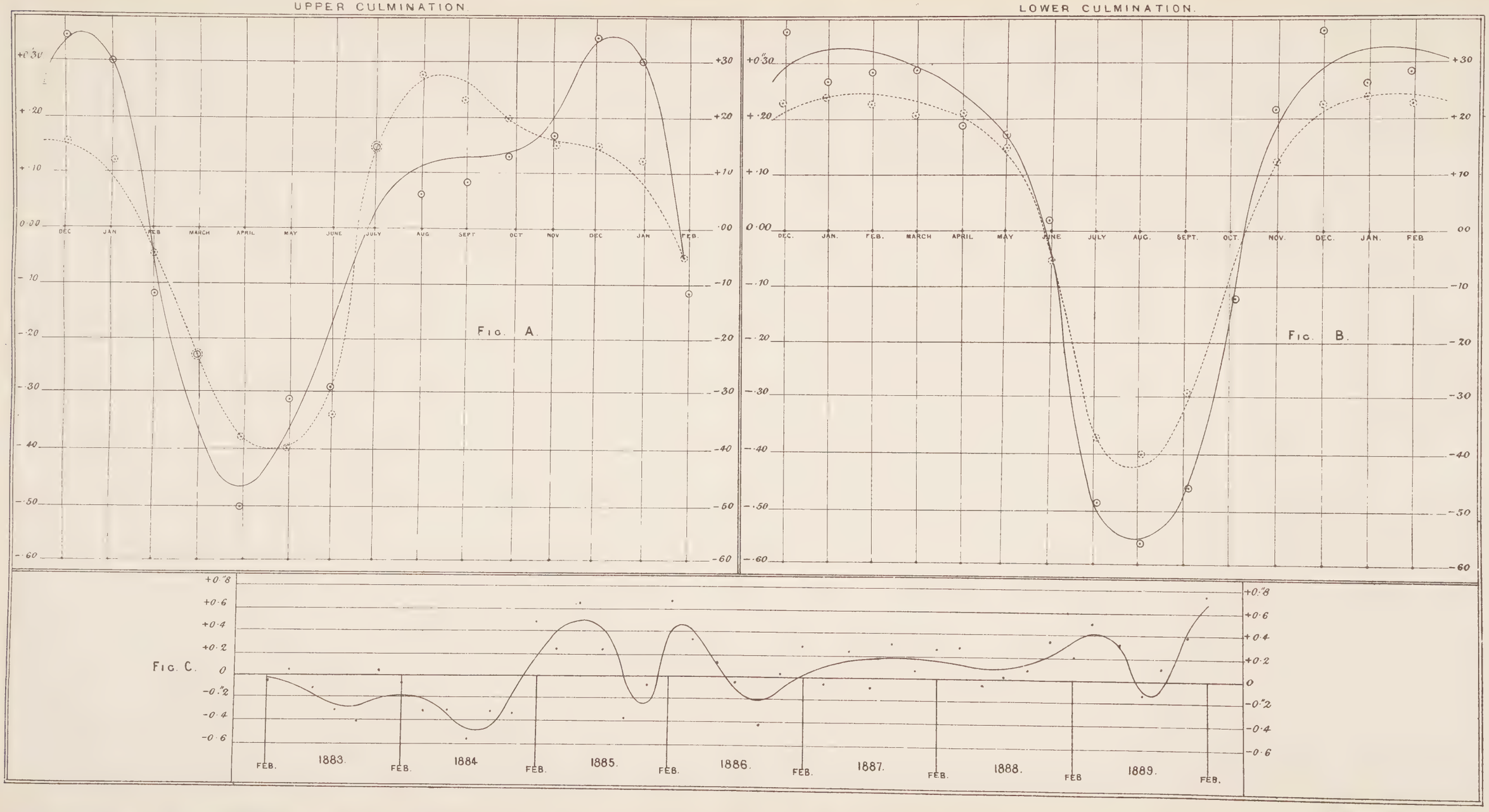

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Table I.

	Zenith Stars.	All the Stars.		Zenith Stars.	All the Stars.
	″	″		″	″
1889, Jan.	17·23	17·19	1889, Sept.	17·53	17·51
Feb.	17·33	17·30	Oct.	17·61	17·52
March	17·43	17·29	Nov.	17·42	17·30
April	17·38	17·34	Dec.	17·14	17·10
May	17·44	17·36	1890, Jan.	17·23	17·11
June	17·54	17·40	Feb.	17·18	17·05
July	17·65	17·50	March	17·11	17·07
Aug.	17·68	17·54	April	17·37	17·15

For every month the latitude from stars near the zenith is somewhat greater than that from all the stars, but the variation of the latitude in both cases is about the same. It is not impossible to conceive a configuration of the strata of the air in the atmosphere, which would cause the same anomaly in the refraction for stars at different distances from the zenith, but it is very improbable that in Berlin, Potsdam, and Prague the strata had at the same time exactly that configuration.

In this state of the question it is of great interest to examine: (1) whether in other observatories the same variation has been observed, (2) whether those variations have a periodic character and had the same values a certain number of years ago.

The best material, particularly for examining the second question, is offered by the observations of zenith distances with the transit circle at Greenwich, which from 1851 till now have been made always in the same manner and under the same conditions. The only change of the instrument was made in August and September 1865, when the opposite sides of the central cube were pierced with perforations; but an influence of that operation on the results of the observations I used is not indicated.

I used for my purpose only the observations of the zenith distances of *Polaris*, because their number is very great and distributed over the whole year, and because by the combination of zenith distances in both culminations one can get results free from the influence of aberration, parallax, &c.

The polar distances of *Polaris* show a strongly-marked annual variation, which has been pointed out by me in 1868 (*Astron. Nachr.* vol. lxxii. p. 241), by Mr. Downing in 1880 (*Monthly Notices R.A.S.* vol. xl. p. 430), by Mr. Thackeray in 1888 and 1889 (*Memoirs R.A.S.* vol. xlix. p. 239, and *Monthly Notices R.A.S.* vol. l. p. 15). That variation is not the same in both culminations; it is therefore certain that it is not wholly the result of a real change in the latitude, and it is, in the first place, necessary to investigate what is probably its cause.

From the interesting discussion published by Mr. Thackeray

and from the paper I published in the *Astron. Nachr.* it is highly probable that at least a part of the variation is connected with the temperature. Mr. Thackeray discusses the following hypotheses as most likely to furnish a possible cause of the annual variation:—

1. That the readings of the thermometer, used in the reductions, may be liable to periodic error owing to position.

2. That the method of adopting the zenith-point correction may lead to periodic error.

3. That the discordances of observation may vary directly with temperature.

4. That the discordances of observation may vary directly with humidity.

In his paper in the *Memoirs R.A.S.* he comes to the following conclusions: that the corrections deduced from the first hypothesis, though making the final results more accordant, do not materially alter the run of the annual variation; that the differences of values between zenith points, derived from the nadir-point observations and from the mean of $\frac{R+D}{2}$ of the North and South reflexion stars, do not satisfy the purposes of his inquiry; that it is possible to explain the discordances by the third and fourth hypotheses, but that there seems to be no means of determining whether the discordances arise from an imperfect correction for changes of temperature, or to the want of a correction for variations in the amount of humidity.

In his paper in the *Monthly Notices R.A.S.* Mr. Thackeray publishes a continuation of his researches, particularly on the influence of temperature and humidity on refraction. From an examination of the results of the polar distances of *Polaris* and the Sun, he states (page 18) that the results of his inquiry "gave no assurance that either correction (for temperature and humidity) was an unmixed advantage." He then determined to see what "effect these corrections would have on the observations of low southern stars, and the answer is apparently decisive; the observed places will allow of neither the one nor the other correction."

At last (page 21) he "assumes that the discordances are not connected with the correction for refraction, that they are still due to temperature, and probably closely connected with changes in the instrument itself, and that they vary as the sin. Z.D."

At the end of his paper he concludes: "A correction depending on temperature, and varying as sin z., will satisfy the discordances in the observations of *Polaris*, it will get rid of an annual variation, also apparently depending on temperature, in the tabular errors of the Sun; as far as it goes, it will tend to bring into greater accordance the errors derived from low southern stars, when arranged in order of temperature, and it will diminish the sum of the squares of the residuals of the R—D formula."

Mr. Thackeray has founded his conclusion, "A correction depending on temperature will satisfy the discordances in the observations of *Polaris*," on the *mean* values of those discordances at equal temperatures in *both* culminations, but that conclusion does not hold good when we consider the culminations *separately*.

In the following table are contained the mean monthly discordances of *Polaris* for the period 1851–1882, and also the mean readings of the ordinary exterior thermometer, taken at the time of observation of *Polaris* and *Polaris* S.P. for the years 1851–1858, from Mr. Thackeray's paper in the *Memoirs R.A.S.* The discordances represent errors of zenith distance. The first of the two series of discordances for each culmination in this table represents the values deduced from the daily results for each year, published in the Greenwich Observations without any correction; the second series represents the same values when they are reduced with a coefficient of aberration 0″·07 greater than Struve's coefficient. According to the researches of Nyrén and Küstner, this correction of the coefficient of aberration is probable.

Table II.

	Upper Culmination.				*Lower Culmination.*		
	Exterior therm.	Discordances. Uncorr.	Discordances. Corrected for Aberration.		Exterior therm.	Discordances. Uncorr.	Discordances. Corrected for Aberration.
	°	″	″		°	″	″
Jan.	39·3	+0·37	+0·30	Jan.	31·3	+0·20	+0·27
Feb.	41·3	−0·07	−0·12	Feb.	31·5	+0·24	+0·29
March	49·2	−0·21	−0·23	March	35·8	+0·27	+0·29
April	54·2	−0·51	−0·50	April	42·0	+0·20	+0·19
May	57·3	−0·35	−0·31	May	49·2	+0·21	+0·17
June	61·8	−0·35	−0·29	June	64·4	+0·08	+0·02
July	55·2	+0·07	+0·14	July	71·9	−0·42	−0·49
Aug.	54·3	+0·01	+0·06	Aug.	71·2	−0·51	−0·56
Sept.	50·2	+0·06	+0·08	Sept.	67·8	−0·44	−0·46
Oct.	47·8	+0·14	+0·13	Oct.	54·4	−0·13	−0·12
Nov.	38·5	+0·21	+0·17	Nov.	40·1	+0·18	+0·22
Dec.	36·8	+0·40	+0·34	Dec.	36·0	+0·30	+0·36

For *Polaris* S.P. there is generally a fair agreement between the discordances and the temperature, with the exception of the two months May and June, for which the observed discordances are about 0″·25 and 0″·40 greater than they should be from the temperatures; but for *Polaris* in upper culmination the same accordance does not exist. The maximum of the discordances occurs

in April, the maximum temperature in June. The discordances at equal temperature in March and September are $-0''.21$ ($-0''.23$) and $+0''.06$ ($+0''.08$), and in April and August $-0''.51$ ($-0''.50$) and $+0''.01$ ($+0''.06$). From these numbers it is clear that it is not possible to represent the discordances in both culminations by an expression depending only on the exterior temperature.

As the proposed hypotheses did not give satisfactory results, I continued my researches in the direction of my paper in the *Astron. Nachr.* vol. lxxii., and have sought the relation between the discordances and the excess of exterior over interior temperature. I employed in that discussion the observations of the years 1851–1882. I should have liked to extend my researches also over the observations in following years, but from 1883 there are but very few readings of the interior thermometer, so that the excess of the exterior over the interior temperature could not be determined.

In the first place I calculated, when possible, from the readings of the interior and exterior thermometer in the "Observations of Zenith Distances" the excess of temperature for each observation of *Polaris*, and formed for *Polaris* and *Polaris* S.P. separately the following values:—

1. The mean value Q of the zenith distances with a positive excess of temperature.
2. The mean value R of the zenith distances with a negative excess of temperature.
3. The mean annual value P of all the zenith distances for which the excess of temperature could be indicated.
4. The mean monthly values P_1, $P_2 \ldots P_{12}$ of the zenith distances for which the excess of temperature could be indicated.

At the same time I formed in the four cases the mean values of the excesses of temperature B, C, A, A_1, $A_2 \ldots A_{12}$.

In Table III. are given the differences R − Q with the differences of the mean excesses of temperature C—B for each year and their weights, the weight of one observation being taken as unity.

Table III.

Upper Culmination.				*Lower Culmination.*			
Year.	R−Q	C−B	Weight.	Year.	R−Q	C−B	Weight.
1851	+0″·27	6°·6	9	1851	+0″·45	5°·6	13
1852	+0·82	6·5	14	1852	+0·66	5·8	15
1853	+0·74	6·3	7	1853	+0·68	5·8	11
1854	+0·23	6·3	17	1854	+0·50	6·2	19
1855	+1·06	6·2	11	1855	+0·84	5·3	13
1856	+0·52	6·0	15	1856	+0·74	7·2	14
1857	+0·72	7·4	18	1857	+0·34	6·1	20
1858	+0·61	8·0	24	1858	+0·48	5·6	19
1859	+0·34	6·0	14	1859	+0·65	6·2	15
1860	+0·61	6·7	9	1860	+0·72	6·8	5
1861	−0·11	5·7	17	1861	+0·20	5·3	13
1862	+0·23	5·5	7	1862	+0·04	4·7	11
1863	+0·32	5·5	13	1863	+0·66	5·8	13
1864	+0·59	5·5	14	1864	+0·91	5·7	5
1865	+0·35	6·8	13	1865	+0·27	4·6	10
1866	+0·32	6·7	8	1866	+0·29	4·0	3
1867	+0·43	5·7	7	1867	+0·06	3·6	6
1868	+0·65	5·7	15	1868	+0·36	7·0	20
1869	+0·59	6·1	8	1869	+0·97	6·7	16
1870	+1·01	8·3	17	1870	+0·93	6·3	14
1871	+0·25	8·3	9	1871	+0·89	5·8	14
1872	+0·51	6·9	15	1872	+0·61	6·4	17
1873	+0·56	6·8	16	1873	+0·48	6·6	18
1874	+1·21	6·7	13	1874	+0·48	5·9	12
1875	+0·46	6·2	9	1875	+0·82	6·1	10
1876	+1·31	6·4	12	1876	+0·83	6·5	13
1877	+0·72	5·7	11	1877	+0·55	4·9	17
1878	+0·52	6·8	8	1878	+0·83	5·8	13
1879	+0·65	6·0	11	1879	+0·58	4·4	9
1880	+0·25	4·9	11	1880	+0·56	6·2	11
1881	+0·95	6·8	11	1881	+0·24	5·8	12
1882	+1·17	6·3	8	1882	+0·68	5·5	7

Taking the mean value of all the years, without regard to the weights, we obtain:—

	R−Q	C−B
	″	°
Polaris	0·60	−6·4
Polaris S.P.	0·57	−5·8

The observations of the years 1851–1864 (discussed *Astron. Nachr.* vol. lxxii.) gave:—

	R−Q	C−B
	″	°
Polaris	0·49	−6·4
Polaris S.P.	0·55	−5·9

The piercing of the cube in 1865 had accordingly no appreciable influence on these results.

In order to study further the relation between the discordances and the excesses of temperature, I formed for each year the differences P_1-P, $P_2-P \ldots A_1-A$, $A_2-A \ldots$ of the annual and the monthly mean values. The weights of these differences for some months are very small; it is therefore desirable to take the means of different years. In combining the results of consecutive years the influence of a real periodic variation of latitude depending on the Eulerian period of 304 days disappears, but as 6×304 days is very nearly equal to five years, the influence of such a variation is each fifth year the same. I have therefore formed the mean monthly discordances for the years 1851, 1856, 1861, for the years 1852..., 1857, 1862..., for the years 1853, 1858, 1863..., for the years 1854, 1859, 1864..., and for the years 1855, 1860, 1865....

Those five series of monthly discordances, with their weights, are contained in Table IV.

TABLE IV.

Upper Culmination.

	1851, 56 . . . 81			1852, 57 . . . 82			1853, 58 . . . 78			1854, 59 . . . 79			1855, 60 . . . 80		
	Discordance.	Excess of Temp.	Weight.	Discordance.	Excess of Temp.	Weight.	Discordance.	Excess of Temp.	Weight.	Discordance.	Excess of Temp.	Weight.	Discordance.	Excess of Temp.	Weight.
	″	°		″	°		″	°		″	°		″	°	
Jan.	+0·41	−1·8	30·3	+0·21	−1·1	36·6	+0·41	−1·0	35·9	+0·47	−1·1	29·1	+0·39	−1·1	29·7
Feb.	+0·09	+0·1	17·8	+0·04	+0·7	19·0	−0·13	+0·7	25·9	−0·22	+0·5	21·5	−0·08	+0·6	29·4
Mar.	−0·16	+2·0	31·3	−0·25	+3·1	26·8	−0·20	+3·7	32·7	−0·31	+2·5	31·9	−0·14	+1·6	23·9
Apr.	−0·37	+3·0	32·1	−0·63	+4·2	31·3	−0·40	+4·4	25·0	−0·62	+4·1	31·5	−0·52	+5·0	35·5
May	−0·41	+4·6	40·7	−0·46	+5·2	24·9	−0·24	+4·3	27·8	−0·13	+3·6	29·5	−0·49	+4·4	27·9
June	−0·16	+3·8	25·7	−0·46	+4·1	25·7	−0·45	+4·1	26·9	−0·37	+3·3	23·1	−0·27	+3·7	21·2
July	−0·12	−2·0	13·3	+0·24	−2·3	17·6	+0·04	−1·3	17·7	−0·07	−0·8	20·4	+0·39	−1·0	9·1
Aug.	+0·05	−3·2	13·0	+0·07	−2·0	10·5	−0·24	−4·0	17·8	−0·08	−3·1	18·2	+0·34	−2·8	14·0
Sept.	+0·16	−2·6	34·3	−0·04	−2·5	34·6	−0·06	−2·5	38·7	+0·06	−2·4	32·1	+0·17	−3·3	37·8
Oct.	−0·05	−2·2	40·2	+0·22	−2·2	51·7	+0·13	−2·2	46·4	+0·34	−2·1	39·5	+0·04	−2·2	32·0
Nov.	+0·27	−1·3	42·2	+0·18	−1·5	36·6	+0·18	−1·8	38·9	+0·14	−1·6	44·0	+0·32	−2·3	26·4
Dec.	+0·32	−2·4	34·6	+0·48	−1·5	36·6	+0·48	−1·9	33·5	+0·32	−1·3	39·0	+0·43	−1·3	21·1

Lower Culmination.

	1851, 56 . . . 81			1852, 57 . . . 82			1853, 58 . . . 78			1854, 59 . . . 79			1855, 60 . . . 80		
	Discordance.	Excess of Temp.	Weight.	Discordance.	Excess of Temp.	Weight.	Discordance.	Excess of Temp.	Weight.	Discordance.	Excess of Temp.	Weight.	Discordance.	Excess of Temp.	Weight.
	″	°		″	°		″	°		″	°		″	°	
Jan.	+0.12	−5.1	8.0	−0.07	−2.2	16.8	+0.88	−3.3	8.7	+0.58	−1.4	7.7	−0.54	−1.5	4.7
Feb.	+0.23	−2.6	9.5	+0.06	−2.8	11.2	−0.06	−2.9	10.1	+0.50	−2.5	11.2	−0.20	−1.5	7.7
Mar.	+0.29	−2.7	27.5	+0.25	−2.2	14.9	+0.09	−2.7	38.1	+0.33	−2.0	36.6	+0.54	−1.8	16.0
Apr.	+0.16	−2.2	40.0	+0.10	−2.4	53.7	+0.20	−2.6	47.8	+0.32	−2.1	48.1	+0.22	−2.4	45.5
May	+0.13	−1.8	54.6	+0.29	−1.4	55 1	+0.22	−2.2	46.7	+0.17	−1.7	64.3	+0 26	−1.7	47.8
June	+0.10	+0.7	42.8	+0.09	+0.4	41.8	−0.10	+0.4	49.1	+0.19	+0.5	37.2	+0.15	+0.4	42.5
July	−0.49	+3.9	32.6	−0.60	+4.1	37 6	−0.28	+4.4	38.2	−0.45	+4.4	28.0	−0.23	+3.1	19 6
Aug.	−0.24	+3.6	38.2	−0.51	+4.4	26.9	−0.43	+4.2	39.0	−0.95	+5.2	31.0	−0.50	+4.7	20.1
Sept.	−0.61	+2.9	24.2	−0.24	+3.0	33.1	−0.46	+3.3	35.4	−0.38	+3.3	35.0	−0.62	+3.3	26.2
Oct.	−0.05	+1.2	35.2	−0.09	+0.9	38.5	+0.09	+0.2	30.5	−0.24	+1.2	36.0	−0.45	+1.3	22.9
Nov.	+0.28	−1.5	32.5	+0.13	−0.9	29.5	+0.36	−2.2	23.4	+0.03	−1.2	35.5	+0.16	−0.8	16.6
Dec.	+0.33	−2.7	14.0	+0.02	−2.0	26.0	+0.37	−2.6	21.5	+0.22	−2.4	26.1	+0.46	−3.4	10.1

If there is a variation of latitude depending on the motion of the instantaneous axis of rotation in 304 days, the discordances of the same months in the different series must show a periodic difference. A mere inspection of these numbers gives no indication of such differences, and that a variation in the ten-month period, if existing, is very small, is also indicated by a discussion of the mean error of weight unity.

I determined first that mean error from the differences of the monthly discordances for the years 1851, 1856, 1861..., and their mean values in the first column of Table IV. and also from the like differences for the other years. The mean value for *Polaris* and *Polaris* S.P. is:—

Mean error ± 0″·89, prob. error ± 0″·60.

Afterwards I determined the mean error from the differences of the mean monthly discordance for each series in Table IV. and their general mean values. I obtained then for *Polaris* and *Polaris* S.P.—

Mean error ± 0″·78, prob. error ± 0″·53.

If there was a systematic difference between the mean monthly discordances in Table IV., the second value of the mean error should be greater than the first, instead of smaller.

The excesses of temperature in the same months of the different year are not the same; and as it seems that the discordances are nearly proportional to the excesses, I have, in the calculation of the mean errors, added to the discordances for the same month a slight correction in order to reduce them to the same excess.

Another determination of the probable error of a zenith distance of *Polaris* is given by Sir G. B. Airy in his "Theory of Errors of Observation," second edition, page 115. He finds—

Probable error ± 0″·57.

I have adopted as the mean error of weight unity—

± 0″·84.

Taking the mean values of the discordances of the same month in the five series of Table IV. with equal weights, the results are entirely free from a periodic variation in 304 days, and there remains but a small influence of the periodic variation indicated by Radau (*Comptes Rendus*, vol. cxi. No. 16) and Helmert (*Astron. Nachr.* vol. cxxvi. p. 217), depending on the motion of the instantaneous axis of rotation around a principal axis of inertia and an annual motion of that principal axis of inertia. As the amount of that periodic variation in 304 days is, however,

as we have seen, very small, we will get more exact results, which are also practically free from the influence of that periodic variation, in combining the partial results in Table IV. with their weights.

The resulting mean values of the discordances with the excesses of temperature and their weights are contained in Table V. I have added in that table for each culmination another column, containing the mean discordances corrected for a slight variation in the coefficient of aberration. It is, as I have already said, probable from the recent researches of Nyrén and Küstner that the true coefficient of aberration is about 20″·51; the coefficient used in the reduction of the Greenwich observations from 1851 to 1856 is 20″·4200, and since the latter year 20″·4451; the mean value for all the years is therefore 20″·440. The numbers in the third column for each culmination represent the discordances corrected for a variation +0″·07 in the coefficient of aberration, or reduced to a value 20″·51 of that coefficient.

TABLE V.

Upper Culmination.

	Discordance. Uncorrected.	Discordance. Corrected for Aberration.	Excess of Temp.	Weight.
	″	″	°	
Jan.	+0·37	+0·30	−1·3	161·6
Feb.	−0·07	−0·12	+0·5	113·6
March	−0·21	−0·23	+2·6	146·6
April	−0·51	−0·50	+4·2	155·4
May	−0·35	−0·31	+4·4	150·8
June	−0·35	−0·29	+3·8	122·6
July	+0·07	+0·14	−1·5	78·1
Aug.	+0·01	+0·06	−3·1	74·3
Sept.	+0·06	+0·08	−2·6	177·5
Oct.	+0·14	+0·13	−2·2	209·8
Nov.	+0·21	+0·17	−1·7	188·1
Dec.	+0·40	+0·34	−1·7	164·8

Lower Culmination.

	Discordance. Uncorrected.	Discordance. Corrected for Aberration.	Excess of Temp.	Weight.
	″	″	°	
Jan.	+0·20	+0·27	−2·7	45·9
Feb.	+0·24	+0·29	−2·5	49·7
March	+0·27	+0·29	−2·3	133·1
April	+0·20	+0·19	−2·3	235·1
May	+0·21	+0·17	−1·7	268·5
June	+0·08	+0·02	+0·5	213·4
July	−0·42	−0·49	+4·1	156·0
Aug.	−0·51	−0·56	+4·4	155·2
Sept.	−0·44	−0·46	+3·2	153·9
Oct.	−0·13	−0·12	+1·0	163·1
Nov.	+0·18	+0·22	−1·4	137·5
Dec.	+0·30	+0·36	−2·5	97·7

In order to see more clearly the connection between those corrected discordances and the excesses of temperature, I have represented both in the following plate (Plate 3, A, B), the first by a continuous, the second by a dotted, line. The negative excesses are drawn in the same direction as the positive values of the discordances, and 1° Fahrenheit and 0″·09 are represented by lines of the same length.

From these curves it is clear, that but a small part of the discordances can be explained by a real variation of latitude, but that there exists a close connection between the discordances and the excesses of temperature, which could be explained by a refraction of the light in entering the observing-room, as I have more fully shown in the *Astron. Nachr.* vol. lxxii.

The discordances can be tolerably well represented by the formula −0″·09 × excess of temperature, but there are still differences greater than the accidental errors. In the hypothesis that the discordances are due to refraction in the observing-room, these differences may be explained by the supposition that the differences of the exterior and interior thermometer are not equal or proportional to the differences of temperature of the air strata, which cause the refraction, or by the supposition that the form of the strata of equal temperature does not remain the same throughout the year. The inspection of the curves for upper culmination from July to December, when the excesses of temperature have about the same values, the discordances on the contrary show differences of 0″·3, and the comparison of the discordances for upper transit in July, August, September, and October, and for lower transit in

November, December, January, February, and March, which have a mean difference of $0''.17$ notwithstanding the mean excesses of temperature are about the same, are not favourable for both suppositions, and a more probable explanation is found in the supposition that the differences are caused by a small real variation of the latitude. Adopting that the part of the discordances depending on the excesses of temperature is represented by $0''.09 \times$ excess of temperature, the remaining differences, with their mean errors, are represented in Table VI.

TABLE VI.

	Upper Culmination.		*Lower Culmination.*		
	Discordance corrected for Temp.	Mean Error. ±	Discordance corrected for Temp.	Mean Error. ±	Mean Discordance U.C. and L.C.
	$''$	$''$	$''$	$''$	$''$
Jan.	+0.18	0.07	+0.03	0.12	+0.10
Feb.	−0.08	0.08	+0.07	0.12	−0.01
Mar.	0.00	0.07	+0.08	0.07	+0.04
Apr.	−0.12	0.07	−0.02	0.05	−0.07
May	+0.09	0.07	+0.02	0.05	+0.05
June	+0.05	0.08	+0.06	0.06	+0.05
July	+0.01	0.10	−0.12	0.07	−0.06
Aug.	−0.22	0.10	−0.16	0.07	−0.19
Sept.	−0.15	0.06	−0.17	0.07	−0.16
Oct.	−0.07	0.06	−0.03	0.07	−0.05
Nov.	+0.02	0.06	+0.09	0.07	+0.05
Dec.	+0.19	0.07	+0.14	0.08	+0.16

Only in four months the differences for the two transits are $0''.01$ greater than their mean errors; in the other months they are much smaller. When we do not adopt $0''.09$, but another value for the coefficient of the excesses of temperature, the agreement between the two culminations will be not so good, but their mean values will not be altered very much.

The parallax of *Polaris* has a small influence on the discordances, but its value is too uncertain to employ it in the reductions.

The numbers in the last column of Table VI. would indicate that the latitude has a minimum in December or January, and a maximum in August or September, about the same epochs as have been deduced from the observations at Berlin, Potsdam, Prague, 1889 and 1890.

We may sum up the conclusions of the interesting researches of Mr. Thackeray and of the first part of my investigation in the following manner:—

1. The monthly discordances in the zenith distances of *Polaris* are for the greater part not caused by a real variation of latitude, but chiefly by an effect of temperature.

2. It is not possible to explain those discordances by an error in the indications of the exterior thermometer, or by an influence depending only on the exterior temperature.

3. The discordances can be explained, for the greater part, by a cause depending on the difference of the exterior and interior temperatures.

4. Probably that cause is a refraction in the observing-room, and its effects are sensibly proportional to those differences of temperature.

5. The discordances corrected for that refraction are about the same for both culminations, and can be explained by a real variation of latitude.

If we assume that the probable causes of the discordances indicated under 4 and 5 are the real ones, and we adopt, after Radau and Helmert, the coexistence of an annual variation in the position of the axis of inertia, and the motion of the instantaneous axis of rotation round that axis of inertia, we may calculate one of the co-ordinates of the curve described by the pole of rotation on the surface of the Earth.

I used for this computation the results of Table IV., which I corrected for the influence of refraction in the observing-room by the formula $0''{\cdot}09 \times$ excess of temperature.

The mean values, with equal weights, of the corresponding numbers in both series offered 60 values for the variation of latitude free from parallax, aberration, &c.

The formula 4 for u' or v' given by Helmert (*Astron. Nach.* vol. cxxvi. p. 220) may be written:—

$$u = \mathrm{A} \sin mt + \mathrm{B} \cos mt + \mathrm{C} \sin \mu t + \mathrm{D} \cos \mu t,$$

where m is the mean annual motion of the Earth, and μ the mean value of the motion of the instantaneous axis of rotation in the ten-month period.

When the unit of t is a mean month, m is 30° and μ 36°. As the numbers in Table IV. are given about for the 15th of each month, the values of t are reckoned from January 15 of one of the years 1851, 1856, 1861, and so on.

The solution of the resulting 60 equations with their weights, by the method of least squares, gives the following results with their mean errors:—

A =	$0''{\cdot}0358$	$\pm 0''{\cdot}0192$
B =	$0''{\cdot}0822$	$\pm 0''{\cdot}0231$
C =	$0''{\cdot}0071$	$\pm 0''{\cdot}0208$
D =	$-0''{\cdot}0047$	$\pm 0''{\cdot}0207$

Substituting these values in the original equations, we find for the mean error of weight unity—

$$\pm 0''{\cdot}90.$$

The fair accordance of this value and of those found formerly in a different manner increases the probability of the suppositions which conducted to that result.

The mean errors of C and D are much greater than the computed values of C and D, so that we may safely put C and D equal to zero; the resulting formula for the variation of latitude is then—

$$u = 0''\cdot0358 \sin mt + 0''\cdot0822 \cos mt;$$

or—

$$u = 0''\cdot0897 \cos (mt - 23^\circ\ 30').$$

When t is expressed in days, from January 15, and $m \frac{360}{365\cdot25}$, we have—

$$u = 0''\cdot0897 \cos m (t - 23\tfrac{5}{6});$$

or reckoning t from January 0, the variation of the latitude is—

$$u = 0''\cdot09 \cos m (t - 39).$$

The latitude has then a minimum on February 9, and a maximum on August 9. The mean error of the constant $0''\cdot09$ of the annual variation is—

$$\pm 0''\cdot0224.$$

The epochs of maximum- and minimum-latitude correspond very nearly with those deduced from the observations made at Berlin, Potsdam, and Prague, 1884–1885, and 1889–1890, but the amplitude of the variation is much smaller. I have, therefore, endeavoured to deduce the variation of latitude for the same years from the Greenwich Observations. I used in this investigation, for the years 1883–1888, the mean north polar distances of *Polaris* in both culminations published in the Greenwich Observations; for the year 1889 and the first two months of 1890 the Astronomer Royal put, with the greatest kindness, the data at my disposal.

The readings of the interior thermometer for those years are with few exceptions not published in the Greenwich Observations, so that I could not determine exactly the excesses of temperature for the different observations. I have therefore adopted for the mean monthly excesses the values published in Table V.

The observations of the years 1883–1889 are all reduced in the same manner, with the same colatitude and refraction, but there is a slight change in the instrument. At the end of 1885 new screws of steel instead of gunmetal were applied by Mr. Simms to the six micrometers of the reading microscopes. The introduction of these new screws has altered the zenith point deduced from nadir observations; but as the method of forming the adopted zenith points consists practically in reducing the zenith point, deduced from the reflected image of the wire, to the mean of the zenith points, deduced from observations of the direct and

reflected images of stars north and south of the zenith, the adopted zenith points depend on the mean of the readings of very different parts of the screws, and will be therefore free from the systematic errors of the screws.

I reduced, therefore, without any correction, all the observations from 1883 to 1889 to the same mean equinox of 1885·0, determined the mean values of the polar distances of *Polaris* in both culminations for the five years 1883–1887, and formed the differences of these values and the mean monthly results of the different years. I added to those differences the correction for the excess of temperature by the formula—

$$0''{\cdot}09 \times \text{excess of temperature in degrees.}$$

In order to obtain results with greater weights, I took the mean values for January and February, March and April, and so on, and combined afterwards the results for upper and lower transits, so that the resulting numbers represent the discordances of latitude. These values, with their weights, are represented in Table VII.

Table VII.

	Discordance corrected for Temp.	Weight.		Discordance corrected for Temp.	Weight.
1883.	″		1886.	″	
Feb.	−0·07	13·8	Oct.	−0·41	24·5
Apr.	+0·02	27·4	Dec.	+0·04	16·8
June	−0·12	31·1	1887.		
Aug.	−0·32	23·3	Feb.	+0·29	10·8
Oct.	−0·41	29·4	Apr.	−0·06	15·8
Dec.	+0·03	31·1	June	+0·25	29·3
1884.			Aug.	−0·08	23·5
Feb.	−0·08	13·8	Oct.	+0·32	23·4
Apr.	−0·32	23·6	Dec.	+0·08	21·7
June	−0·32	38·7	1888.		
Aug.	−0·58	14·7	Feb.	+0·27	7·9
Oct.	−0·32	27·5	Apr.	+0·28	9·0
Dec.	−0·34	23·6	June	−0·04	29·2
1885.			Aug.	+0·03	5·0
Feb.	+0·48	10·0	Oct.	+0·09	26·4
Apr.	+0·25	33·2	Dec.	+0·35	23·5
June	+0·66	31·2	1889.		
Aug.	+0·25	15·7	Feb.	+0·20	6·0
Oct.	−0·38	19·8	Apr.	+0·51	13·7
Dec.	−0·08	16·9	June	+0·32	29·4
1886.			Aug.	−0·14	14·5
Feb.	+0·68	12·8	Oct.	+0·11	23·3
Apr.	+0·33	21·5	Dec.	+0·41	13·7
June	+0·11	26·3	1890.		
Aug.	−0·08	10·0	Feb.	+0·78	12·6

The numbers of this table have been laid down in a graphical representation, and fig. C shows the variation of latitude from February 1883 to February 1890.

From the table and the diagram it seems that there is a great difference between the latitude in the year 1884 and the beginning of 1885. In both years the same elements of reduction, the same refraction, and the same errors of division have been used. The correction to the direct and reflexion observations, deduced from the discordances of reflexion and direct results (the flexure included), is—

1884, Dir. Obs. $-0''.026+0''.658$ sin Z.D.
Refl. Obs. $+0''.026-0''.498$ sin Z.D.
1885, Dir. Obs. $-0''.018+0''.687$ sin Z.D.
Refl. Obs. $+0''.018-0''.527$ sin Z.D.

The correction to each nadir observation, in order to reduce them to the mean of North and South stars, is in 1884 $-0''.45$, in 1885 $-0''.36$. In the adopted zenith points the nadir observations enter with a weight 1, and the star observations with a weight 4, so that the difference of the two corrections has no appreciable influence on the zenith points.

There is therefore no reason to seek the cause of the differences of the results in both years in the reductions, and it is very probable that they are caused by a real variation of latitude.

It seems also that there has been a variation of latitude in the years 1889–1890, with a maximum in August. The mean errors of the results in Table VII. are—

1889 February	$\pm 0''.34$	1889 October	$\pm 0''.18$
April	0.23	December	0.23
June	0.16	1890 February	0.24
August	0.22		

They show that, though the variation of latitude is not certain, it is, however, probable. The variations in 1884–1885 and 1889–1890 agree well with those found in Germany.

From this part of the investigation we may conclude—

1. That it is probable that the observations of *Polaris* at Greenwich confirm the variations of latitude observed elsewhere in 1884–1885 and 1889–1890.

2. That there is a very strong probability that the variations in these years had an exceptional character, and do not agree with the annual variations, deduced from the observations of *Polaris* at Greenwich during the period 1851–1882.

This last point may have some interest, as it indicates that there has been probably some perturbation in the position of the principal axis of inertia. A slight perturbation will, however, be sufficient to explain the greater amplitude of the variation.

Helmert assumes in his interesting paper (*Astron. Nachr.* vol. cxxvi.) that the pole of the principal axis of inertia (pole of inertia) has an annual elliptic motion around its mean place (centre); its co-ordinates are—

$$x = p\cos(mt+r)\,;\quad y = q\sin(mt+r).$$

The co-ordinates of the pole of the instantaneous axis of rotation (pole of rotation) are then—

$$u = \frac{\mu^2 p + \mu m q}{\mu^2 - m^2}\cos(mt+r) + \mathrm{A}\cos(\mu t + \mathrm{B})\,;$$

$$v = \frac{\mu^2 q + \mu m p}{\mu^2 - m^2}\sin(mt+r) + \mathrm{A}\sin(\mu t + \mathrm{B}).$$

When we admit, as is probable, q equal to zero, or the motion of the pole of inertia rectilinear; and we put A=0, as we deduced from the Greenwich Observations, we have for $mt+r=0$—

$$x = p\,;\quad y = 0\,;\quad u = p\frac{\mu^2}{\mu^2 - m^2}\,;\quad v = 0.$$

The pole of inertia and the pole of motion are, therefore, at the same instant in a straight line with the centre, and at their greatest elongations; the proportion of their distances to the centre is—

$$1 : \frac{\mu^2}{\mu^2 - m^2}.$$

When we further make the hypothesis that by meteorological processes the pole of inertia remains some time, say 2·5 months, in that greatest elongation, it is easy to calculate the motion of the pole of rotation. During the 2·5 months it will describe around the pole of inertia an arc of 90° with a radius

$$p\frac{m^2}{\mu^2 - m^2}\,;$$

and when, from the end of that period of 2·5 months, the pole of inertia begins again its rectilinear annual motion, we must give to A and B such values that for $mt+r=0$ we have—

$$u = p \text{ and } v = p\frac{m^2}{\mu^2 - m^2}.$$

We find then—

$$\mathrm{B} = 135^\circ + \frac{\mu}{m}r\,;\quad \mathrm{A} = p\frac{m^2\sqrt{2}}{\mu^2 - m^2}.$$

From the Greenwich Observations we deduce that 0″·09 lies between:

$$p\frac{\mu^2}{\mu^2 - m^2} \text{ and } p\frac{\mu m}{\mu^2 - m^2},$$

or putting for μ and m their values, 0″·09 lies between $\frac{36}{11}p$ and $\frac{30}{11}p$; p will be therefore nearly 0″·03 and A 0″·096.

The co-ordinates of the pole of rotation are then—

$$u = 0''{\cdot}098 \cos(mt + r) + 0''{\cdot}096 \cos(\mu t + 135° + \frac{\mu}{m} r);$$

$$v = 0''{\cdot}098 \sin(mt + r) + 0''{\cdot}096 \sin(\mu t + 135° + \frac{\mu}{m} r).$$

The greatest distance of the pole of rotation from the centre is now $0''{\cdot}194$ instead of $0''{\cdot}09$.

Leiden: 1891 *March.*

Addendum.

In answer to some remarks which Mr. Thackeray has had the courtesy to address to me, I add the following:—

In my paper I said that Mr. Thackeray based the conclusions in his last paper in the *Monthly Notices*, vol. l., on the mean of the polar distances of *Polaris* in upper and lower culmination, because in that paper, wherein he gives the result of "a more careful discussion of the lower and higher temperatures, and an extension of the range of temperature in the latter direction," he communicates only these means. Mr. Thackeray writes me that he has, however, satisfied himself as to the fair agreement of the result of both culminations; but as the monthly discordances, particularly of the upper culmination, I communicated in my paper, cannot be fairly represented by an error proportional to the temperature, I must conclude that the agreement between temperature and discordance found by Mr. Thackeray is an accidental one, and that the real cause of the discordances is not the exterior temperature, but must be sought elsewhere. I have also tried to represent the monthly discordances by a term proportional to the temperature and a real variation of latitude (naturally the same for both culminations), but I could not obtain satisfactory results.

In the year 1875 a re-examination of the values of successive revolutions of the screws of the microscope micrometers indicated a decided inequality in those values ("Christie, On the Effect of Wear in the Micrometer Screws of the Greenwich Transit Circle," *Monthly Notices*, vol. xxxvii. p. 18). The conclusion arrived at by Mr. Christie is "that it would appear that by far the greater portion of the wear in the micrometer screws has taken place in the seventeen years preceding 1868, and that, except in the part between 0^r and 1^r, the errors have not sensibly changed since that date."

As my results depend only on the differences of the monthly and the annual means, they will not be very much influenced by that error, but before combining the results of all the years, I had first considered separately the mean monthly discordances of the years 1868–74 (in the year 1875 a correction for wear is already added to the daily results). I found for those discordances the following values, to which I have added the mean discordances for the whole period, with their weights and their differences:—

Upper Culmination.

Month.	1868–74. Discordance.	1868–74. Weight.	1851–82. Discordance.	1851–82. Weight.	Diff.
	″		″		″
Jan.	+0·40	33·8	+0·37	161·6	+0·03
Feb.	+0·01	20·8	−0·07	113·6	+0·08
Mar.	−0·03	29·4	−0·21	146·6	+0·18
Apr.	−0·68	37·6	−0·51	155·4	−0·17
May	−0·44	35·5	−0·35	150·8	−0·09
June	−0·41	27·8	−0·35	122·6	−0·06
July	−0·41	10·7	+0·07	78·1	−0·48
Aug.	+0·40	6·8	+0·01	74·3	+0·39
Sept.	+0·05	41·7	+0·06	177·5	−0·01
Oct.	+0·12	57·7	+0·14	209·8	−0·02
Nov.	+0·26	44·8	+0·21	188·1	+0·05
Dec.	+0·48	42·6	+0·40	164·8	+0·08

Lower Culmination.

Month.	1868–74. Discordance.	1868–74. Weight.	1851–82. Discordance.	1851–82. Weight.	Diff.
	″		″		″
Jan.	+0·52	5·8	+0·20	45·9	+0·32
Feb.		0			
Mar.	+0·46	25·5	+0·27	133·1	+0·19
Apr.	+0·32	56·8	+0·20	235·1	+0·12
May	+0·13	67·3	+0·21	268·5	−0·08
June	−0·02	49·0	+0·08	213·4	−0·10
July	−0·41	52·2	−0·42	156·0	+0·01
Aug.	−0·64	33·0	−0·51	155·2	−0·13
Sept.	−0·35	37·5	−0·44	153·9	+0·09
Oct.	−0·23	37·6	−0·13	163·1	−0·10
Nov.	+0·26	34·8	+0·18	137·5	+0·08
Dec.	+0·51	30·5	+0·30	97·7	+0·21

From the differences of the discordances in the two periods, I found for the mean error of the unit of weight in both culminations the same value $\pm 0''\cdot 67$. As the value of that mean error formerly found is $\pm 0''\cdot 84$, there is no systematic difference, and I concluded that the wear of the screws had no appreciable influence on the discordances. I retained, therefore, the mean result of all the years.

I do not believe that the readings of the exterior and interior thermometer indicate exactly the temperature of the exterior air and of the object-glass, or rather of the ocular, as there is probably also a refraction in the tube; but as a correction, proportional to the differences of both thermometers, explains the greater part of the discordances, I think it probable that the mean

differences of both thermometers are proportional to the excess of temperature of the strata which cause the refraction in the observing-room.

Comparison of the Star-places of the Greenwich Ten-year Catalogue with those of the Second Melbourne General Catalogue, and with those of the Cape Catalogue for 1880. By A. M. W. Downing, M.A.

The epoch of the Greenwich Ten-year Catalogue and that of the Second Melbourne General Catalogue being the same (1880), the comparison between the places of the stars common to both—472 in number—is a very easy matter. The effect of a difference in the values of the assumed proper motions in any particular cases has been neglected in making the comparison, it being assumed that, in the mean, the effect of such differences would be inappreciable.

The following *errata* have been detected during the progress of the work:—

Greenwich, No. 1,627, *Lalande* 19,433,
for R.A. $9^h\ 49^m\ 11^s{\cdot}586$ *read* $9^h\ 49^m\ 12^s{\cdot}586$.
Melbourne, No. 735, γ *Hydræ*,
for R.A. $13^h\ 12^m\ 25^s.02$ *read* $13^h\ 12^m\ 24^s{\cdot}02$.

Table I., given below, exhibits the differences Greenwich-Melbourne when the stars are arranged in order of N.P.D., and grouped as shown. Table II. gives the same differences when the stars are arranged in order of R.A., taken in groups of 1^h each.

Table I.

Extent of Group.	$\Delta\alpha$	$\Delta\delta$	No. of Stars in Group.
° °	s	"	
40–50	−·009	−0·56	22
50–60	−·009	−0·52	13
60–65	+·005	+0·31	24
65–70	+·003	+0·75	23
70–75	+·014	+0·96	14
75–80	+·001	+0·87	21
80–85	−·019	+0·68	27
85–90	−·017	+0·48	30
90–95	−·012	+0·62	42
95–100	−·003	+1·05	47
100–105	+·016	+1·30	67
105–110	+·042	+1·13	63
110–115	+·055	+1·34	42
115–120	+·071	+1·48	14
120–125	+·087	+2·05	23
40–125	+·015	+0·90	472

TABLE II.

Extent of Group.	$\Delta\alpha$	$\Delta\delta$	No. of Stars in Group.
h h	s	″	
0–1	+·021	+0·54	15
1–2	+·028	+1·29	17
2–3	+·053	+1·10	18
3–4	+·039	+0·68	22
4–5	−·001	+1·19	19
5–6	−·023	+0·61	26
6–7	−·003	+0·79	20
7–8	+·011	+0·98	21
8–9	+·008	+0·53	16
9–10	+·006	+1·09	18
10–11	+·025	+0·94	16
11–12	+·007	+0·72	16
12–13	+·015	+0·79	18
13–14	+·013	+0·90	16
14–15	+·004	+0·71	20
15–16	−·013	+0·34	15
16–17	+·022	+0·91	18
17–18	+·006	+0·73	17
18–19	−·001	+0·69	18
19–20	+·041	+0·72	21
20–21	+·013	+1·03	30
21–22	+·037	+1·05	19
22–23	+·028	+1·31	21
23–24	+·028	+1·44	35
0–24	+·015	+0·90	472

The following table gives the probable errors of a difference between the Catalogue places of a star, in R.A. and N.P.D. respectively, at different N.P.D.'s :—

TABLE III.

N.P.D.	ϵ_α	$\epsilon_\alpha \sin$ N.P.D.	ϵ_δ	No. of Stars in Group.
° °	s	s	"	
40–50	·036	·025	1·24	22
50–60	·044	·036	0·41	13
60–65	·024	·021	0·43	24
65–70	·024	·022	0·41	23
70–75	·030	·029	0·33	14
75–80	·016	·016	0·28	21
80–85	·028	·028	0·41	27
85–90	·025	·025	0·30	30
90–95	·033	·033	0·49	42
95–100	·037	·037	0·46	47
100–105	·043	·042	0·54	67
105–110	·041	·039	0·47	63
110–115	·040	·036	0·56	42
115–120	·042	·037	0·43	14
120–125	·055	·046	1·08	23

The mean value of $\epsilon_\alpha \sin$ N.P.D. is $^s·031$, and that of ϵ_δ is $0''·52$. Assuming that the places of stars in the two catalogues are equally affected by accidental errors, it follows that the mean probable errors of a R.A. and N.P.D. in either are $\pm\, ^s·022$ cosec N.P.D. and $\pm\, 0''·37$ respectively.

The differences exhibited in Tables I. and II. above, in R.A. and N.P.D. respectively, have been laid down as points on cross-ruled paper, and curves drawn through them, from which the differences corresponding to any R.A. or to any N.P.D. between the extreme limits can be read off. To each of the differences arranged in order of R.A. has been applied the mean difference ($+^s·015$ and $+0''·90$ in R.A. and N.P.D. respectively), with reversed sign, before entry in Table IV. below; so that the difference in either R.A. or N.P.D., corresponding to any position, is the sum of the quantities taken from Tables IV. and V. It is further to be remarked that the N.P.D.'s of the Second Melbourne General Catalogue, from N.P.D. 37° 50′ to 127° 50′, are corrected by the quantity $-0''·149 + 0·00914$ R, where R is the refraction of the *Tabulæ Regiomontanæ*. This was done "for the sake of uniformity," a similar correction having been applied to the N.P.D.'s of the First Melbourne General Catalogue, as the result of an examination of certain Melbourne observations. It appears, however, from a discussion published in *Monthly Notices*, vol. xli. pp. 346–357, that the conclusions previously arrived at on this point require considerable modification. Accordingly, in the comparison of the N.P.D.'s arranged

in order of N.P.D. in Table V. given below, whilst Column I. gives the comparison of Catalogue places as published, Column II. gives the comparison with the Melbourne places reduced with the refractions of the *Tabulæ Regiomontanæ*, and the corresponding correction applied to the value of the adopted latitude.

Column II. is, of course, the one that ought to be used in any discussion concerning the accuracy of the refractions adopted at Greenwich.

The differences Greenwich-Cape given below are derived from the values of Greenwich-Melbourne here given, combined with the values Melbourne-Cape published in *Monthly Notices*, vol. l. pp. 485, 486.

The comparatively large differences in R.A., in Table V., from N.P.D. 110° to 120°, and which are of the *same sign* in the comparisons of Greenwich with both Melbourne and the Cape, will be noticed.

Table IV.

R.A.	Greenwich-Melbourne.		Greenwich-Cape.	
h	s	"	s	"
0·0	+·010	+0·12	−·011	−0·13
1·0	+·012	+0·10	−·005	−0·10
2·0	+·024	+0·18	+·013	+0·04
3·0	+·023	+0·09	+·020	+0·08
4·0	+·006	+0·02	+·019	−0·02
5·0	−·018	−0·02	−·002	−0·22
6·0	−·025	−0·10	−·011	−0·25
7·0	−·015	−0·08	+·001	−0·12
8·0	−·006	−0·10	+·004	−0·15
9·0	−·005	−0·06	−·012	−0·09
10·0	−·001	+0·02	−·025	+0·10
11·0	·000	−0·06	−·042	+0·12
12·0	−·001	−0·10	−·042	+0·18
13·0	−·002	−0·08	−·034	+0·28
14·0	−·007	−0·14	−·039	+0·28
15·0	−·014	−0·28	−·038	+0·15
16·0	−·011	−0·26	−·021	+0·11
17·0	−·005	−0·14	−·005	+0·21
18·0	−·004	−0·12	+·008	+0·20
19·0	+·003	−0·12	+·013	+0·15
20·0	+·011	−0·04	+·026	+0·21
21·0	+·012	+0·12	+·045	+0·33
22·0	+·015	+0·30	+·043	+0·33
23·0	+·015	+0·32	+·005	+0·09

TABLE V.

N.P.D.	Greenwich-Melbourne.			Greenwich-Cape.	
		I.	II.		
°	s	″	″	s	″
50	−·009	−0·54	+1·71		
55	−·005	−0·50	+1·05	−·008	+0·09
60	·000	0·00	+1·15	−·004	+0·33
65	+·005	+0·53	+1·41	·000	+0·51
70	+·008	+0·88	+1·58	+·003	+0·53
75	+·004	+0·90	+1·45	+·002	+0·59
80	−·009	+0·76	+1·20	−·001	+0·59
85	−·016	+0·58	+0·92	−·005	+0·40
90	−·014	+0·56	+0·82	−·012	+0·17
95	−·007	+0·82	+1·01	−·011	+0·15
100	+·008	+1·20	+1·33	+·002	+0·35
105	+·027	+1·24	+1·32	+·014	+0·44
110	+·049	+1·24	+1·26	+·030	+0·54
115	+·065	+1·40	+1·37	+·054	+0·75
120	+·079	+1·77	+1·69	+·069	+1·14

Blackheath:
February 1891.

Note on the Parallax of β Aurigæ. By the Rev. Professor Pritchard, D.D., F.R.S.

Attention having been called to this star by the remarkable spectroscopic observations that have been made at Harvard and Potsdam, preparations were made for the early determination of the parallax. These observations necessarily come within the scheme for the determination of the relative parallax of the stars of the 2nd magnitude, in process of reduction at Oxford.

This star has been referred to two others, whose magnitudes are respectively 8·8 and 10·2 magnitude, and whose approximate co-ordinates are—

	Pos. Ang.	Distance.
	° ′	″
a	91 50	710·9
b	269 10	945·2

The resulting parallax from each of the stars is—

a	+0″·065 ± 0″·024
b	+0·059 ± 0·025

The identity of these relative parallaxes leads to the conclusion that the stars of comparison are either situated on a sphere

having *β Aurigæ* for its centre, or they belong to a remote system of stars in which *β Aurigæ* has no part, and this identity may possibly, therefore, indicate an absolute parallax.

Assuming the conclusions of Professor Vogel's determination of the distance between the centres of the two components of *β Aurigæ* at 1,650,000 geographical miles, it appears that the greatest angular separation of the two components is no more than $0''{\cdot}005$.

1891 *March* 12.

The Companions of Aldebaran. By S. W. Burnham.

I have recently finished a set of measures of the companions of *Aldebaran* with the large telescope, and these taken in connection with prior measures are of considerable interest in showing the relations existing between the bright star and its several attendants. The nearest companion was found with the Chicago 18½-inch refractor in 1877, and this is now shown to have the same proper motion as the principal star; a result which would not be expected considering the distance and great difference in magnitudes. Both distance and position angle appear to have remained unchanged, the small difference in measures being fully accounted for by the extreme minuteness of the companion and the difficulty of measuring it so near a first-magnitude star. It was a very difficult object to see with the Chicago telescope, and might easily be overlooked even with the 36-inch refractor. I give below all the measures that have been made of this star.

The more distant Herschel companion has been observed for more than a hundred years, and the change shown by the measures has usually been ascribed solely to the proper motion of *Aldebaran*. The distinguished French astronomer Flammarion was the first to notice the fact that the well-known proper motion of A could not account for the relative change, and therefore came to the conclusion that B must have a proper motion of its own, and in a different direction. Of the correctness of this view there can be no doubt, and the amount and direction of the relative displacement of C should be as well known as of most stars. This motion is almost exactly half that of A, and is perhaps larger than that of any known star as faint as the eleventh magnitude which is not connected and moving with some brighter component.

In looking at this object in 1888 with the 36-inch, I found that the Herschel companion was also double, or had a very faint attendant a little more than $2''$ distant. This is too difficult for most telescopes, and I am not aware that it has been seen elsewhere. It was measured in 1888, and again this year.

The several positions of B and C, as shown by the measures,

are given accurately to scale on the diagram (Plate 4). The annual proper motion of A is taken as 0″·188 in the direction of 164°·4. The central position of A is for the date of Struve's measure of C (1836); and the later measures are laid off from the actual place of A along the line of its movement, as determined by the proper motion already given. In the same manner the positions of B are laid down, the first and last measures in each case being connected with A by the lines shown in the diagram.

The following are the measures used:—

A and B (β 550).

	°	″		
1877·89	109·0	30·45	β	3*n*
1878·00	110·5	31·26	Hl	3*n*
1880·11	111·2	31·46	β	2*n*
1888·82	109·5	30·90	β	2*n*
1890·87	109·0	31·34	β	3*n*

A and C ($\frac{H}{S}$ VI. 66).

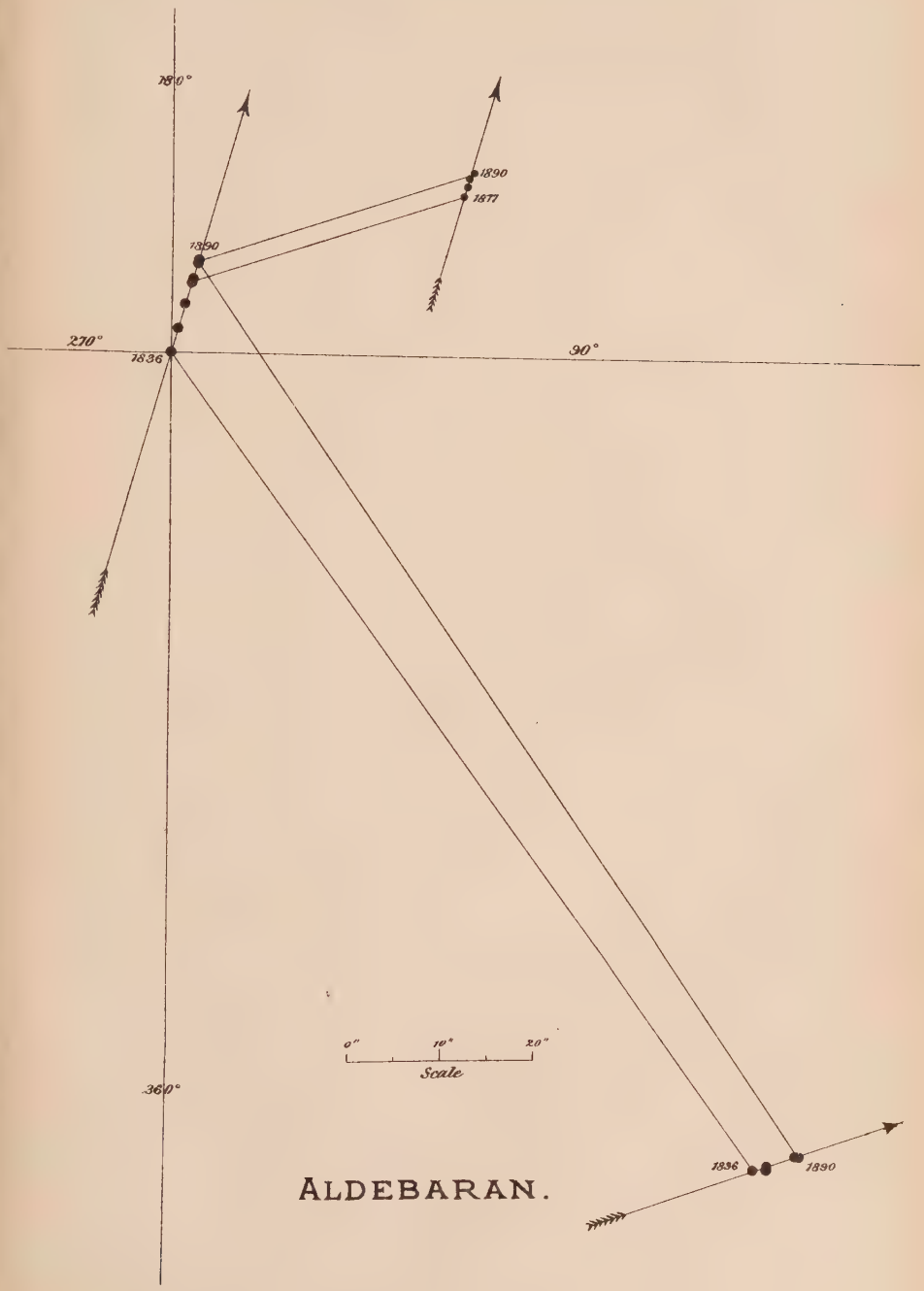
	°	″		
1836·06	36·0	109·04	Σ	2*n*
1851·40	35·5	111·60	OΣ	
1864·24	34·8	112·79	De	6*n*
1887·00	34·5	116·27	Hl	20*n*
1889·98	34·6	116·97	β	7*n*

C and D (β 1031).

	°	″		
1888·81	281·1	2·34	β	3*n*
1890·86	279·1	1·84	β	4*n*

It is apparent from the measures of B that its proper motion is substantially, and probably exactly, the same as that of A. The mean of the five sets of measures of this companion for the angle is 109°·8, and for the distance 31″·08. The differences between these values and the separate measures are really very small when the extreme faintness of the companion is taken into account.

From the measures of C we find that this companion has an annual motion of 0″·095 in the direction of about 109°·6. I have not used Herschel's measure of 1781, making the angle 36°·0, and the distance 87″·75. At best this would be only approximate. By the assumed motion of the stars, the angle at this time should have been 38°, and the distance 102″. Evidently at one time these stars were much nearer together; and by carrying the motions back it is shown that the minimum distance of 40″ occurred about A.D. 1130. At this time the



ALDEBARAN.

distance of BC was less than 11″; and about the middle of that century it was a little less than 9″.

The measures of CD do not cover a sufficient time to tell with certainty what the relation of D is to this group. As the angle of CD is nearly in the line of the motion of C, the distance between these stars should be about 0″·2 more in 1890 than in 1888, if D does not share the motion of C; but from the measures this distance is 0″·5 less at the former date. This would appear to indicate that the proper motion was common to both stars, and that there was a relative change due to some other cause. Measures made two or three years hence will at once settle this question.

The Herschel companion is the star generally used for the determination of the differential parallax of *Aldebaran*; but as the proper motion of the small star does not appear to have been taken into account, the result obtained would seem to be materially affected by an error from this source.

Mount Hamilton: 1890 *December* 25.

The Orbit of κ Pegasi (β 989). By S. W. Burnham.

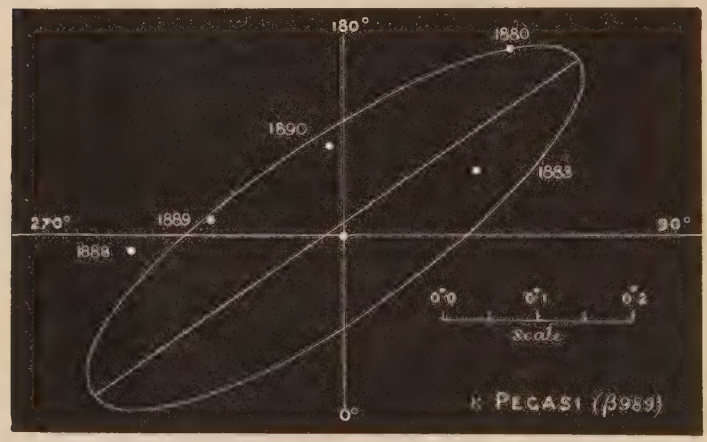
On August 12, 1880, while observing with the 18·5-inch refractor of the Dearborn Observatory, I came across the wide pair, *κ Pegasi*, and at once saw that the large star was a very close double. The measures made on this and following nights gave a distance of 0″·27, and this I thought was more likely to be too large than otherwise (*Monthly Notices*, xli. p. 33). I was unable to give any further attention to this star until the commencement of my measures made at the Lick Observatory, and the extreme difficulty of measuring so close a pair seems to have deterred other observers, with a single exception, from doing anything with it. The only record of any other observation of any kind is found in the work of the late Dr. Engelmann, of Leipzig. When we consider that his telescope had an aperture of only about 7·5 inches, it is almost wonderful that he could get even an approximate position, notwithstanding it was a Clark objective, and shows his great skill as an observer, and the superior defining qualities of his instrument. It is unfortunate that we have so little to represent the extraordinary motion of this pair in a few years through an angle of 230°. Since I have been at Mount Hamilton I have measured the close pair each year with the 36-inch refractor. During the measures of the past year it was extremely difficult, and was a severe test of the power of the great telescope with the very best atmospheric conditions. The highest powers were, of course, used, and it was necessary not only to exercise the utmost care in

focussing, but to keep the head in such a position that the line joining the eyes was parallel to the line of the two stars.

The following are the measures of the close pair :—

1880·68	137°·9	0″·27	β	4*n*
1883·02	116·0	0·16	En.	1*n*
1888·78	274·7	0·23	β	3*n*
1889·51	262·3	0·14	β	4*n*
1890·57	187·1	0·10	β	4*n*

It is plain from the few observations already made that we have a binary system in very rapid motion. It is too soon perhaps to expect from the data given anything more than a very approximate solution of the orbit by any method of investigation, but a graphical representation of the measures will at least give a general idea of the relation between the components.



I have laid down these measures with all possible accuracy on a large scale (1″=20 inches), and then drawn after repeated trials the apparent ellipse shown on the accompanying diagram. This ellipse satisfies the test of equal areas in equal times. The areas described by the radius vector between the position of 1880–89 and 1889–90 are exactly proportional to the times (1 : 8·33); and as the variation of these positions from the path described by the curve is far within the ordinary errors of observation in a much easier star than this, I think the figure may be taken as a fair approximation to the apparent motion of the components. According to this diagram, the distance at the time of Engelmann's measure was 0″·23, and the angle 113°; while for the position of 1888 the distance is 0″·21, and the position angle 281°. The other measures are substantially exact with reference to the assumed path of the secondary star. The

components differ in brightness by something less than one magnitude, and when they are separated by only a quarter of a second, the difference is not very plain. It might be suspected that the angle of 1880 should be increased 180°, or that the measures of the last three years should be diminished by that amount. Upon referring to the original observations, I find that I took special pains to give the proper quadrant at the time of discovery, as well as in the measures of 1888 and 1889; so that I feel every confidence in the accuracy of the observations in this respect.

If this figure correctly represents the relative motions, it is evident that the period is shorter than that of any known star in the heavens. It should make one revolution in a little more than eleven years, and by the time it is observable again during the present year it should have nearly completed one revolution, and have about the same angle and distance as at the time of discovery in 1880.

From the projected orbit we get the following :—

Major axis	0″·636
Minor axis	0″·187
Maximum distance	0″·32 (1881·7)
Minimum distance	0″·08 (1884·6)
Period	11·13 years
Position angle of major axis ...	125°·4

Apparently the real orbit is nearly circular, and makes an angle of about 75° with the line of sight. Whether the period of rotation is as short as that indicated, the motion is certainly very rapid, and the object one of the most interesting of its class. The measures which I hope to make during the coming summer will probably settle most of these questions. It should be comparatively easy to measure this year, as the distance will be not less than 0″·2.

This star has been known as a wide double star since the time of Sir William Herschel, who detected the companion, a star of ninth magnitude, in 1786. He described it as "extremely unequal, the small star almost north, but a little preceding." It was not measured until 1831, when Struve observed it, and incorporated it in his great catalogue as Σ2,824. The distance of the small star at that time was 11″. It has been frequently measured since, the distance now being a little more than 12″, with a very slow diminution of the position angle. An examination of these measures shows beyond all question that the apparent motion of the small star is rectilinear and uniform. The displacement during the interval between Struve's measures in 1831 and mine in 1888 amounts to 2″·08 in the direction of 252°.

This is undoubtedly the movement of the principal star, which has, therefore, an annual proper motion of 0″·036 in the direction of 72°.

On the Determination of Double Star Orbits from Spectroscopic Observations of the Velocity in the Line of Sight. By Arthur A. Rambaut, M.A.

(*Communicated by Sir. R. S. Ball.*)

I have shown in a paper which I read before the Royal Irish Academy in May 1886 how the relative velocity of the components of a double star is connected with the parallax and the elements of the orbit. In a later paper, published in the *Monthly Notices* of the Royal Astronomical Society for March 1890, I put the results in a more convenient form, and pointed out what velocities we might expect to find in the already known optical doubles.[1] The smallness of these velocities, however, seemed to show that, except perhaps in a very few cases, the spectroscopic observations of these stars were likely to prove extremely difficult.

At the time of writing the latter paper, although Professor Vogel had demonstrated the duplicity of *Algol*, and Professor Pickering the duplicity of *β Aurigæ* and *ζ Ursæ Majoris*, the results were so novel and startling that, although the idea occurred to me of solving the inverse problem—viz., to obtain the orbit from the spectroscopic observations alone—it did not seem to me that the observations were reliable enough to warrant the expenditure of the time which the solution of the question would require.

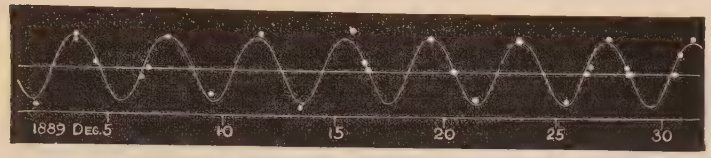
The beautiful results, however, obtained by Professor Pickering in the case of *β Aurigæ*, and published in the Fourth Annual Report of the Henry Draper Memorial, seem to throw a wholly new light on the question.

The frontispiece of this report contains five figures, the last four of which are reproductions of some of his photographic spectra, and exhibit the nature of the data on which his results depend. These prove at a glance that there is no question about the periodic displacement of the lines, and also show that the amount of the displacement is capable of measurement with very considerable accuracy.

It is, however, the first of these figures with which we are principally concerned at present. This is a curve in which the

[1] At the time of writing this I was not aware of a paper by Professor Niven in the *Monthly Notices* of the R.A.S., May 1874, dealing with the subject, in which he publishes formulæ almost identical with those given in the communications mentioned above.

time is taken as the abscissa and the relative velocity in the line of sight as ordinate. The portion of the curve given covers the whole of the month of December 1889, containing 27 measures of the displacement of the lines, and in no case does the actually



observed displacement differ from that derived from the curve by more than the accidental errors of measurement.

A glance at the curve shows that there is a periodic displacement occurring in about four days. To determine the period with greater accuracy it is necessary to take a series of observations extending over a long time, and to divide the interval which has elapsed by the number of periods which have occurred. For this purpose, of course, the longer the star is under observation, the more accurately can the period be determined. From the portion of the curve given in the report I find for the period:

$$P = 3{\cdot}968 \text{ days.}$$

We can now determine the form of the curve with greater accuracy. For if we take any arbitrary epoch as the zero of abscissæ and subtract once, twice, . . . n times P from the time, we can reduce all the observations within the same period, and thus obtain a very large number of points through which to draw the curve of velocities.

From Professor Pickering's report, treating the observations in the way just described, I obtain the following figures:—

t.	V.	t.	V.	t.	V.
0·48	−8·6	0·47	−8·6	0·74	0·0
0·94	+6·3	0·07	+8·8	0·79	+2·0
0·96	+7·6	0·20	+1·2	0·01	+8·0
0·17	+1·2	0·23	0·0	0·20	+1·4
0·67	−2·1	0·00	+7·7	0·22	0·0
0·76	0·0	0·24	0·0	0·26	−0·3
0·97	+7·1	0·48	−6·4	0·74	−0·3
0·46	−6·0	0·00	+7·8	0·81	+4·7
0·05	+8·3	0·50	−6·6	0·96	+8·0

In drawing the curve of velocities from these data there are two conditions which must be fulfilled, the reasons for which will appear when we come to determine the form of the orbit. *The*

first of these is that the area of the curve above the axis of t shall be equal to that below the same line; *the second*, that the area contained between the curve, the axis of t and the ordinate corresponding to maximum positive velocity, shall be equal to that contained between the curve, the axis of t, and the ordinate corresponding to maximum negative velocity.

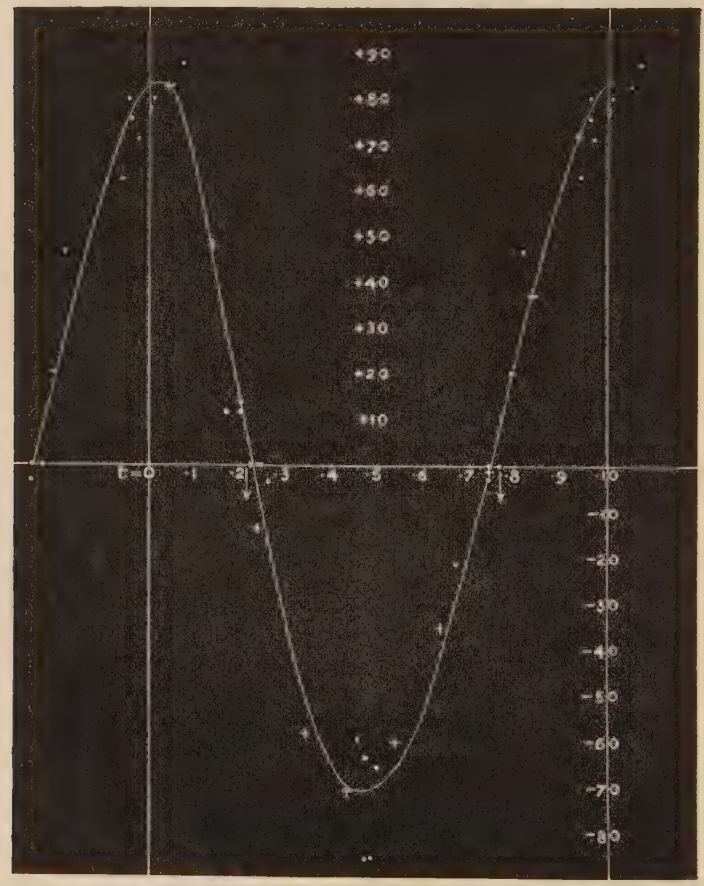


Fig. 1. Curve of Velocities.

With these two conditions in view, the curve shown in fig. 1 has been drawn from the figures given above.

I shall refer to it as *the curve of velocities*.

To Determine the Form of the Orbit.

If we take the line of sight as the axis of x, and the centre of the principal star as the origin of coordinates, we have, if V is

the relative velocity of the components in the line of sight, the equation

$$\frac{dx}{dt} = V,$$

and consequently

$$x = \int V dt \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (1)$$

The following considerations will enable us to determine the limits between which the integral is to be taken.

If we take the line of nodes as the axis of y, we have x equal to zero when the companion star is passing through this line. Now I have shown in my paper, already referred to, in the *Monthly Notices*, that when the companion is in this position the velocity in the line of sight is greatest. Hence it follows that if τ is the epoch corresponding to a maximum velocity, we have

$$x = \int_{\tau}^{t} V dt \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (2)$$

But when the companion is passing through the line of nodes on the other side of the primary, we have again $x=0$, and the velocity in the line of sight again a maximum, but in the opposite direction. Hence, if τ' is the epoch corresponding to this configuration, we have

$$0 = \int_{\tau}^{\tau'} V dt.$$

But the expression $\int_{\tau}^{\tau'} V dt$ is the area of the curve in fig. 1 between the greatest positive and the greatest negative ordinates; and since we see that this must be equal to zero, we obtain the second condition mentioned above for guidance in drawing our curve of velocities. Further, since the value of x is again zero at the line of nodes after a complete revolution has taken place, we see that we have

$$\int_{\tau'}^{\tau + P} V dt = 0;$$

or, what amounts to the same thing, the area of the curve of velocities, measured from the greatest negative to the greatest positive ordinate, is equal to zero. This, taken in connection with what we have already obtained, gives the first condition mentioned above, viz. that the area above the axis of t is equal to that below the same line.

In drawing this curve and computing the area contained between it and the axes, perhaps the most convenient method, and one which is quite sufficiently accurate for our present purpose, considering the nature of the data, is to plot down the observed

velocities on millimetre paper to any convenient scale, taking 100^{mm} to represent the whole period. We then take a sheet of ordinary ruled writing-paper and rule it with eleven equidistant lines, so as to divide it up into a number of spaces, as shown in the table given below. For every square centimetre in fig. 1, therefore, we have a corresponding space in the table, and if we enter in each of these spaces the number of square millimetres inclosed by the curve in the corresponding square on fig. 1, we have a register of the area of the curve in a very convenient form, which enables us to see where the shape of the curve is in error, and to correct it as may appear necessary, so as to fulfil the two conditions mentioned above, without the trouble of going back and recomputing the whole area of the curve at each alteration.

	0	1	2	3	4	5	6	7	8	9	10		
+90	16	...	...	...	...	...	...	...	...	4	20		
+80	74	...	...	...	...	...	...	...	...	47	121		
+70	98	3	...	...	...	...	...	...	...	84	186		
+60	100	20	...	...	...	...	...	...	14	100	234		
+50	100	38	...	...	...	...	...	...	42	100	280		
+40	100	58	...	...	...	...	...	...	68	100	326		
+30	100	77	...	...	...	...	...	1	93	100	371		
+20	100	95	1	...	...	...	...	17	100	100	413		
+10	100	100	27	...	...	...	...	40	100	100	467	2418	
0	...	...	63	100	100	100	100	37	...	...	500		
−10	...	...	41	100	100	100	100	10	...	...	451		
−20	...	...	21	100	100	100	86	...	...	...	407		
−30	...	...	3	98	100	100	58	...	...	...	359		
−40	...	...	...	76	100	100	27	...	...	...	303		
−50	...	...	...	47	100	94	2	...	...	...	243		
−60	...	...	...	9	94	46	...	...	...	...	149		
−70	...	...	...	...	6	...	...	...	...	...	6	2418	
−80	788	391	156	530	700	640	373	105	417	736	4836		

Hitherto we have only been concerned with the abscissæ, but in addition to the equation (1) we have the relation

$$x\frac{dy}{dt}-y\frac{dx}{dt}=c, \text{ a constant,}$$

which may be written in the form

$$y=cx\left[\mathrm{B}+\int\frac{dt}{x^2}\right] \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (3)$$

This equation will enable us to determine y if we have any means of obtaining the values of the constants c and B.

In order to determine B it is necessary to refer to the equation

$$\pi\mathrm{V}=\frac{la\sin\gamma}{\mathrm{P}\sqrt{1-e^2}}\left[e\cos\lambda+\cos(\theta-\lambda)\right] \quad . \quad . \quad . \quad . \quad . \quad . \quad (4)$$

which I have obtained in my previous paper.

As I have pointed out there, if $\theta-\lambda=0$ or π, *i.e.* if the body is passing through the line of nodes, the velocity in the line of sight is a maximum. Let these two values of V be V_1 and V_2. We thus obtain

$$\frac{\pi}{2}(\mathrm{V}_1+\mathrm{V}_2)=\frac{la\sin\gamma}{\mathrm{P}\sqrt{1-e^2}}\cdot e\cos\lambda.$$

But when $y=0$ the line joining the two components—*i.e.* the radius vector—must be at right angles to the line of nodes, and consequently $\cos(\theta-\lambda)=0$. Hence, if V_3 is the velocity in the line of sight when in this position we have

$$\mathrm{V}_3=\tfrac{1}{2}(\mathrm{V}_1+\mathrm{V}_2),$$

or, *the ordinate* y *is zero at the moment when the velocity is a mean between the greatest positive and the greatest negative velocities.* Denoting this epoch, which we can determine from the curve of velocities, by the letter τ_0 we have

$$y=cx\int_{\tau_0}^{t}\frac{dt}{x^2} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (5)$$

We have not the means of determining from the spectroscopic observations what is the value of c, but if we take it to be any convenient factor, we shall obtain proportional values of y from equation (5), which, in connection with the values of x derived from equation (2), will enable us to construct an ellipse which is *an* orthographic projection of the real orbit on a plane passing through the line of nodes, although the angle between it and the real orbit is indeterminate.

Now this being an orthographic projection, the centre of the projected, is the projection of the centre of the real, ellipse, and the ratios of the various parts of the major axis of the real orbit are unaltered by projection. Consequently, if C (fig. 3) is the centre of the ellipse obtained as described above, P the primary,

which is also the origin of coordinates, and A and B the points in which the line CP meets the ellipse, we have

$$\frac{CP}{CA} = e \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (6)$$

We have also from equation (4) the relations

$$V_1 = \frac{la \sin \gamma}{P\pi \sqrt{1-e^2}} (e \cos \lambda + 1), \text{ and } V_2 = \frac{la \sin \gamma}{P\pi \sqrt{1-e^2}} (e \cos \lambda - 1);$$

whence we obtain

$$e \cos \lambda = \frac{V_1 + V_2}{V_1 - V_2} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (7)$$

from which λ may be determined.

Again, if $\bar{a}$ represents the semi-major axis in miles, and R the radius of the earth's orbit, we have

$$\frac{\bar{a}}{R} = \frac{a}{\pi},$$

and equation (4) becomes

$$\frac{PRV\sqrt{1-e^2}}{l(e \cos \lambda + \cos(\theta - \lambda))} = \bar{a} \sin \gamma \quad . \quad . \quad . \quad . \quad . \quad . \quad (8)$$

from which $\bar{a} \sin \gamma$ may be determined, all the quantities on the left-hand side of the equation being already known. It will, however, be sufficient in general to take V_1 and V_2 from which to determine $\bar{a} \sin \gamma$. Thus we have

$$PRV_1\sqrt{1-e^2} = l\bar{a} \sin \gamma (e \cos \lambda + 1);$$

$$PRV_2\sqrt{1-e^2} = l\bar{a} \sin \gamma (e \cos \lambda - 1);$$

whence

$$\bar{a} \sin \gamma = \frac{PR\sqrt{1-e^2}}{2l} (V_1 - V_2) \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (9)$$

There still remains one element which the data at our disposal enable us to determine. This is T, the epoch of periastron passage. We must, however, first determine the epoch of the passage through the node, which we shall call ϵ, and which may at once be read off the curve of velocities in fig. 1, being, in fact, the time of maximum velocity. Knowing the eccentricity we can then find the mean anomaly nt corresponding to the true anomaly λ. We have also got the mean motion equal to $\frac{2\pi}{P}$, whence we obtain

$$T = \epsilon \pm \frac{nt\,P}{2\pi} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (10)$$

In the case before us, from the velocities given above and the curve in fig. 1, which is drawn by means of them, we have the time of greatest velocity (*i.e.* ϵ) equal to $0{\cdot}02 \times P$ *later* than

the epoch which we have taken as the zero of abscissæ. The latter epoch is December 2·65, and since $0{\cdot}02 \times P = 0{\cdot}08$ days, we have

$$\epsilon = \text{Dec. } 2{\cdot}73.$$

Again, measuring the area of the curve from the ordinate corresponding to this epoch, we have the following values of

$$x, \frac{1000}{x}, \text{ and } \left(\frac{1000}{x}\right)^2 :—$$

t	x	$\frac{1000}{x}$	$\left(\frac{1000}{x}\right)^2$	t	x	$\frac{1000}{x}$	$\left(\frac{1000}{x}\right)^2$
0·06	+ 330	+ 3·030	+ 9·18	0·56	− 711	− 1·406	+ 1·98
·08	485	2·062	4·25	·58	833	1·200	1·44
·10	624	1·603	2·57	·60	945	1·058	1·12
·12	745	1·342	1·80	·62	1045	0·957	0·92
·14	845	1·183	1·40	·64	1131	0·884	0·78
·16	922	1·085	1·18	·66	1204	0·831	0·69
·18	979	1·021	1·04	·68	1264	0·791	0·63
·20	1015	0·985	0·97	·70	1310	0·763	0·58
·22	1032	0·969	0·94	·72	1340	0·746	0·56
·24	1030	0·971	0·94	·74	1354	0·739	0·55
·26	1008	0·992	0·98	·76	1352	0·740	0·55
·28	966	1·035	1·07	·78	1334	0·750	0·56
·30	905	1·105	1·22	·80	1297	0·771	0·59
·32	828	1·208	1·46	·82	1243	0·805	0·65
·34	735	1·361	1·85	·84	1173	0·853	0·73
·36	629	1·590	2·53	·86	1088	0·919	0·84
·38	511	1·957	3·83	·88	988	1·012	1·02
·40	+ 385	+ 2·597	+ 6·74	·90	874	1·144	1·31
				·92	748	1·337	1·79
0·50	− 310	− 3·226	+ 10·41	·94	− 608	− 1·645	+ 2·71
·52	448	2·232	4·98				
·54	582	1·718	2·95				

It will be noticed that the values of x from $t=0{\cdot}40$ to $t=0{\cdot}50$ and from $t=0{\cdot}94$ to $t=0{\cdot}06$ have been omitted from this table. This has been done in consequence of the fact that, x becoming very small, the corresponding values of $\frac{1000}{x}$ and $\left(\frac{1000}{x}\right)^2$ become too large to be manageable; in fact the curve in fig. 2 has a pair of infinite branches corresponding to these epochs.

The next step in the process is to plot down as ordinates the values of $\left(\frac{1000}{x}\right)^2$, which are given in the last column of this table, taking the corresponding values of t as abscissæ. We thus obtain the interpolating curve for

$$c\int_{\tau_0}^{t}\frac{dt}{x^2}$$

shown in fig. 2. To find the epoch τ_0 it is necessary to revert to fig. 1, and we find that $V_1=+84$ and $V_2=-71$, whence

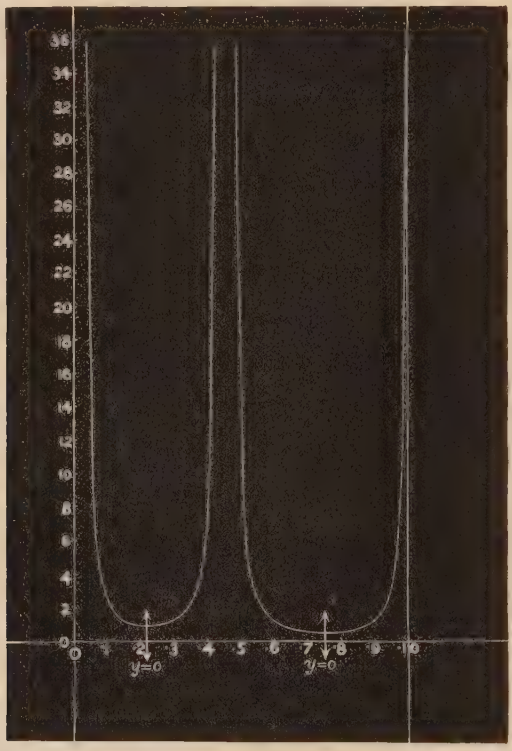


Fig. 2. Interpolating Curve for $c\int_{\tau_0}^{t}\frac{dt}{x^2}$

$V_3=+6{\cdot}5$, and the epochs corresponding to this value of V are $t=0{\cdot}215$ and $t=0{\cdot}761$. These two epochs are marked in fig. 2 with double-headed arrows. Calculating the areas contained between these ordinates, and the ordinates corresponding to the epochs 0·02, 0·04, &c. we get the following values for

$$c\int_{\tau_0}^{t}\frac{dt}{x^2}.$$

t	$c\int_{\tau_0}^{t}\frac{dt}{x^2}$	t	$c\int_{\tau_0}^{t}\frac{dt}{x^2}$	t	$c\int_{\tau_0}^{t}\frac{dt}{x^2}$
0·06	−163	0·36	+ 92·5	0·72	− 8
·08	106	·38	123·5	·74	3
·10	76	·40	+173·5	·76	+ 2
·12	56			·78	7
·14	41	·50	−210	·80	12
·16	29	·52	138	·82	18
·18	18	·54	102	·84	25
·20	− 8	·56	79	·86	33
·22	+ 1	·58	63	·88	42
·24	10	·60	51	·90	53
·26	19·5	·62	41	·92	68·5
·28	29·5	·64	33	·94	+90
·30	40·5	·66	26		
·32	54	·68	19		
·34	+ 71	·70	− 13		

Since the value of c is perfectly arbitrary, we may for convenience divide these numbers by 100.

We thus obtain, by means of equation (5), the following corresponding values of x and y:—

t	x	y	t	x	y
0·06	+3·30	−5·38	·56	− 7·11	+ 5·62
·08	4·85	5·14	·58	8·33	5·25
·10	6·24	4·71	·60	9·45	4·82
·12	7·45	4·17	·62	10·45	4·28
·14	8·45	3·46	·64	11·31	3·73
·16	9·22	2·67	·66	12·04	3·12
·18	9·79	1·76	·68	12·64	2·40
·20	10·15	−0·81	·70	13·10	1·70
·22	10·32	+0·10	·72	13·40	1·07
·24	10·30	1·03	·74	13·54	+0·41
·26	10·08	1·97	·76	13·52	−0·27
·28	9·66	2·85	·78	13·34	0·93
·30	9·05	3·67	·80	12·97	1·56
·32	8·28	4·47	·82	12·43	2·23
·34	7·35	5·22	·84	11·73	2·92
·36	6·29	5·82	·86	10·88	3·60
·38	5·11	6·32	·88	9·88	4·15
·40	3·85	+6·68	·90	8·74	4·63
			·92	7·48	5·12
0·50	−3·10	+6·51	·94	− 6·08	−5·47
·52	4·48	6·18			
·54	5·82	5·94			

With these values of x and y the positions marked in fig. 3 have been plotted down, and the "apparent" ellipse drawn

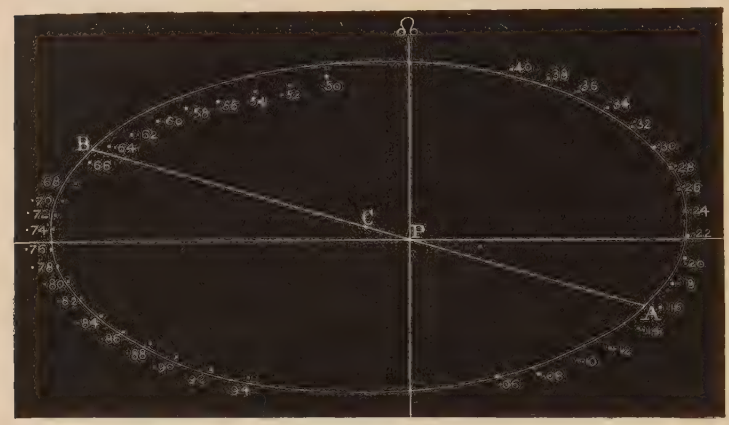


Fig. 3. "Apparent" Ellipse.

through them. Finding C the centre of this ellipse, and drawing CP to meet the curve in the point A, we have

$$\frac{CP}{CA} = 0{\cdot}156 = e$$

by equation (6).

We have also $V_1+V_2=13$ and $V_1-V_2=155$: hence by equation (7)

$$e \cos \lambda = \frac{13}{155} = 0{\cdot}0839.$$

and substituting the value just found for e, we find

$$\lambda = \pm\ 57°{\cdot}43.$$

In computing $\bar{a} \sin \gamma$, it must be remembered that the unit in terms of which we have expressed V hitherto is perfectly arbitrary. But when the displacements of the lines are expressed in wave-lengths we can at once convert the values of V into miles. In the Henry Draper Report the wave-lengths are not given, but Professor Pickering mentions that the greatest velocity amounts to 150 miles per second. This would make $\frac{1}{2}(V_1-V_2)=139{\cdot}5$ miles per second. Hence we obtain, by means of equation (9), —remembering that in that equation P is expressed in years, and that consequently we must put $\frac{3{\cdot}968}{365}$ for its value—

$$\bar{a} \sin \gamma = 0{\cdot}081 \times \text{R}.$$

If we assume R to be 93,000,000 miles, this corresponds to a distance of $7\frac{1}{2}$ millions. What the actual value of $\bar{a}$ may be the spectroscope does not enable us to determine, since in most

cases the value of γ will remain wholly indeterminate. In some special cases, however, such as that of *Algol*, where the variation of the lines synchronises with a variation in the brightness of the star, we may assume that γ is very nearly 90°, and that accordingly $\bar{a} \sin \gamma$ may be taken as the actual value of the semi-axis major.

We have still to compute the value of T. For this purpose we have the equation

$$\tan \tfrac{1}{2} u = \sqrt{\frac{1-e}{1+e}} \tan \tfrac{1}{2} \theta,$$

whence we obtain $u = 50°{\cdot}2$, when $\theta = \lambda$. Also the mean anomaly corresponding to this is $nt = 43°{\cdot}3$. Hence we obtain, by means of equation (10)

$$\begin{aligned} T &= \text{Dec. } 2{\cdot}65 + 0{\cdot}02 \,.\, P + 0{\cdot}12 \,.\, P. \\ &= \text{Dec. } 2{\cdot}65 + 0{\cdot}14 \,.\, P = \text{Dec. } 3{\cdot}21. \end{aligned}$$

We thus have the following elements of the orbit of *β Aurigæ* :—

P = 3·968 days;	$e = 0{\cdot}156$;
T = 1889, Dec. 3·21;	$\lambda = 57°{\cdot}43$;

and

$$\bar{a} \sin \gamma = 0{\cdot}081 \times R = 7{,}500{,}000 \text{ miles } \pm .$$

In order to test how far these elements will give results agreeing with the data from which they are derived, I have computed the velocity at intervals of a tenth of a period from the epoch of periastron passage. This occurs at $t = 0{\cdot}14$, as we have already seen.

I accordingly obtain the following table of results :—

t	V_c	V_o	t	V_c	V_o
0·04	+83·0	+83·0	0·54	−60·2	−65·7
·14	+48·2	+45·2	·64	−35·2	−40·0
·24	−14·2	− 7·0	·74	− 1·3	− 2·3
·34	−58·5	−51·0	·84	+37·7	+38·0
·44	−71·0	−70·5	·94	+72·1	+72·2

in which V_c denotes the computed velocity, and V_o that read from the curve in fig. 1. The points corresponding to the values of V_c are marked in fig. 1 by small crosses, from which it will be seen that on the whole they agree fairly well with the curve of velocities.

It will also be observed that the greatest discrepancies occur in what I have called the negative part of the curve. [I may,

however, remark in passing that positive and negative velocities are only relative terms in cases like the present, where the lines in the spectrum are of sensibly equal brightness, since the sign of the velocity will wholly depend on the choice we make between the lines as to which shall be considered as belonging to the primary and which to the satellite.] That these discrepancies should occur is hardly to be wondered at considering the scarcity of observations to guide us in drawing the curve in this region. In the positive part, where the observations are more numerous, the shape of the curve seems to have been hit off with very considerable accuracy, as the computed velocities lie very close to it indeed. A glance, also, will show that a very small alteration in the form of the negative portion of the curve would bring it into conformity with the computed points without doing much violence to any of the observed data, and I have no doubt that a curve might easily be drawn which would agree as well with the observed velocities as that shown in fig. 1, and at the same time give more consistent results. As, however, the velocities which I have used in constructing my curve are obtained by measuring the ordinates in Professor Pickering's report, and are, in consequence of the small scale on which his curve is given, affected with considerable errors, it does not appear advisable to push the calculation any further till the numerical results obtained by Professor Pickering are available. I have lately heard from Professor Pickering to the effect that the definitive measures upon the photographs of ζ *Ursæ Majoris* and β *Aurigæ* are in progress, and that he hopes before long to print their results with conclusions derived from them with regard to the orbits of the components of these stars. When these results appear I hope to be able to obtain more accurate values for the quantities P, T, e, λ, and $\bar{a}$ sin γ by the method pointed out above. In the meanwhile, perhaps, the results given in this preliminary notice, and the method of treating the question, may not be without value to those interested in the subject.

One point which my examination of the question seems to indicate very clearly is that the observations should be taken not so much at equal intervals of time, but as much as possible so that the points derived from them may lie equally thick along all parts of the curve of velocities, or, in other words, so that all parts of the curve may be determined with equal accuracy. In fig. 1 it will be seen that the majority of the observations are grouped about the positions of positive and negative maxima, whereas my results show that it is of equal importance to fix the exact time of the coincidence of the lines as well as the epoch at which the velocity is an arithmetic mean between its two extreme values.

I may remark, in conclusion, that in determining the orbit of stars of the *Algol* type, in which one of the components only is

bright enough to form a spectral image on the photographic plate, and in which consequently its displacement has to be determined by comparing it with an artificial line, the treatment of the observations will be somewhat different. In this respect, stars such as *Sirius*, for instance, will come under the same head, if we suppose the variations in their velocity in the line of sight to be due to orbital motion. In this class of star the *whole* velocity in the line of sight is measured, as Professor Vogel has done so skilfully in the case of *Algol*, and this is composed of two parts, viz: the orbital motion relative to the centre of gravity of the system, and the absolute motion of this point, the latter of which may be assumed to be constant in magnitude and direction.

If we have sufficient and accurate enough observations to determine the curve of velocities with certainty, it will be possible to separate the orbital motion of the brighter component from the absolute motion of the system by the first of the two conditions mentioned above on p. 318. For if we plot down the velocities as in fig. 1, the curve may or may not cut the axis of t, which represents the zero of total velocity, according as the orbital is greater or less than the absolute motion. But we have seen above that the line representing the zero of orbital velocity must cut the curve, so that the areas above and below it may be equal. Accordingly, if we draw a line parallel to the axis of t, to satisfy this condition, the distance of this line from the axis of t will represent the absolute motion of the system, and the distance from it to any point on the curve will represent the velocity due to the orbital motion in the corresponding position.

Although the materials are almost ludicrously inadequate to such an investigation, I have attempted to obtain some results from the six spectrographic observations of *Algol* published by Professor Vogel in the *Astronomische Nachrichten*, No. 2,947. I find that the motion of the centre of gravity is about $-0{\cdot}7$ or $-0{\cdot}8$ German geographical miles—Professor Vogel finds $-0{\cdot}5$ on the hypothesis of a circular orbit—and that the eccentricity is something between $\frac{1}{2}$ and $\frac{1}{3}$.

It must, however, be understood that these figures are but little better than mere guesses, on account of the paucity of observations, notwithstanding the great accuracy and value of those which are available.

January 7, 1891.

Additional Note.

When the lines are equal in brightness, as in the case of β *Aurigæ*, there is an ambiguity with regard to the sign of λ, and consequently, at first sight, with regard to the sign in equation (10),

since there are no means of determining whether the velocity is positive or negative in any given position: it is, in fact, positive for one component and negative for another, and there is no means of discriminating between the two. If, however, one of them is fainter than the other, we may confine our attention to the former, and we are then able to state that if the displacement is towards the red end of the spectrum the velocity is positive (*i.e.* the body is receding from us), and conversely.

In any case, however, the expression given for $e \cos \lambda$, given in equation (7), is positive if V_1 is greater than V_2. Consequently, if we take ϵ to be the time of passage through the node at which the velocity is greatest (which we may call ☊), λ will lie in the first or fourth quadrant, but there is no means of deciding, in the case of lines of equal brightness, which of these values for λ we are to choose. A positive value for λ with a rotation in one direction will give the same results as a negative value for λ with a rotation in the other direction. The question is, therefore, whether the motion is from periastron to ☊, or from ☊ to periastron. The following considerations will enable us to decide this point:—

The times of maximum velocity and the two epochs (τ_0), at which the velocity is a mean between its extreme values, mark four points on the orbit, the radii-vectores to which divide the orbit into four sectors, each of which contains a right angle. It is easy to prove that the periastron must fall in that sector whose area is least. We thus see that the time of periastron passage will fall in the shortest of the four intervals into which the period is divided by the four epochs, marked by the two maximum velocities and by the velocity which is a mean between its two maximum values. This shortest interval will always be either that immediately following or immediately preceding ϵ. In the former case we take the upper, in the latter we take the lower, sign in equation (10).

Double Star Measures at Windsor, New South Wales, 1889 and 1890. By John Tebbutt.

This communication contains the results of my double star measures during the years 1889 and 1890. The Grubb 8-inch equatoreal was employed throughout. The column headed "Hour-angles" gives the hour-angles between which the measures were made, and the last column the weights assigned from a consideration of the conditions under which the observations were made: 1 denotes an unusually bad condition and 5 an unusually good one. In the observations numbered 1, 6, 7, 24, 25 the components were estimated to be exactly equal. Observations 20 and 23 were made before sunset, and 2, 3, 4, 8, 13, 14, 21, 22, 29 in twilight. In observation 12 the driving-clock did not act well, and the measures were very inconsistent. The rapid angular motion of *Lalande* 4219, as indicated by the Washington, Leander McCormick, and Pinner observations, is not confirmed by the measures obtained here. The orbit of γ *Coronæ Australis* is at present far from being satisfactorily determined. Mr. Powell, in his paper published in the *Monthly Notices* for March last, states that the Windsor measures of distance are considerably greater than they should be. A practised observer will, however, be satisfied, by a mere glance at the components, that the distance is much greater than that shown by Mr. Powell's orbit. Mr. Burnham, in *Astron. Nachr.* Band 124, p. 74, gives the distance for 1889·41 as $1''\cdot79$. The following errata occur in my Double Star Results in the *Monthly Notices* for November 1889:—Page 25, *for* Lac. 5147 *read* α' Crucis and Lac. 5147; page 26, *for* 1888·320 *read* 1888·326.

Double Star Measures at Windsor, New South Wales, 1889 and 1890.

No.	Star.	Observed Magnitude.	Approx. Place of Star. R.A. h m	Dec. S. ° ′	Date of Obs.	Position-angle.	No. of Obs.	Distance.	No. of Obs.	Mag. Power.	Hour-angles. h m	h m	Weight.
1	*p* Eridani	6, 6	1 36	56 45	1889·852	226°·8	10	″ ...	...	230	1 42 E	1 30 E	4
2	,,	...	,,	,,	1889·882	226·6	10	...	...	230	2 38 E	2 30 E	4
3	,,	...	,,	,,	1889·884	...	...	7·07	10	230	2 50 E	2 36 E	4
4	,,	...	,,	,,	1889·884	227·5	10	...	...	230	2 36 E	2 26 E	4
5	,,	...	,,	,,	1889·904	...	...	6·92	10	170	2 10 E	1 54 E	4
6	,,	...	,,	,,	1890·819	...	...	7·15	10	170	2 21 E	2 6 E	4
7	,,	...	,,	,,	1890·819	226 9	10	...	...	300	2 6 E	1 40 E	4
8	,,	...	,,	,,	1890·832	227 4	10	...	...	300	4 14 E	4 3 E	4
9	Lalande, 4219	8½. 9	2 11	18 44	1890·857	...	...	1·86	10	170	1 14 E	0 53 E	3
10	,,	...	,,	,,	1890·857	343·2	10	...	...	230	0 19 E	0 6 W	2
11	,,	8, 8½	,,	,,	1890 923	344·8	10	...	...	230	1 3 E	0 36 E	3
12	,,	...	,,	,,	1890·980	339·6	10	...	...	230	1 22 W	1 56 W	2
13	γ Centauri	...	12 35	48 21	1890·361	358·9	10	...	...	300	4 7 E	3 42 E	4
14	,,	...	,,	,,	1890·361	359·0	10	1·84	8	500			
15	*h* 4634	9, 10	13 50	55 30	1890·359	17·6	10	12·87	7	140	2 11 E	1 43 E	4
16	α Centauri	...	14 32	60 23	1890·359	...	...	18·75	7	140	2 21 E	1 43 E	4
17	,,	...	,,	,,	1890·359	205·2	10	...	...	230			
18	,,	...	,,	,,	1890·463	...	...	18·42	10	130	1 23 E	0 59 E	3
19	,,	...	,,	,,	1890·463	205·2	10	...	...	140	0 59 E	0 29 E	3

No.	Star.	Observed Magnitude.	Approx. Place of Star. R.A. h m	Dec. S. ° ′	Date of Obs.	Position-angle. °	No. of Obs.	Distance.	No. of Obs.	Mag. Power.	Hour-angles. h m	h m	Weight.
20	α Centauri	...	14 32	60 23	1890·734	...	...	18″·60	10	170	3 15 W	3 30 W	3
21	,,	...	,,	,,	1890·734	204·6	10	...	...	300	3 40 W	3 49 W	3
22	,,	...	,,	,,	1890·734	...	...	18·77	10	300	3 59 W	4 12 W	3
23	,,	...	,,	,,	1890·750	...	...	18·71	10	...	3 32 W	3 50 W	3
24	Brisb. 5784	9, 9	16 33	60 43	1890·734	116·6	10	...	...	230	3 52 W	4 15 W	4
25	,,	...	,,	,,	1890·734	...	...	3·50	10	170	4 27 W	4 43 W	4
26	Brisb. 6556	...	18 54	37 13	1889·849	282·7	8	...	...	140	4 18 W	4 44 W	4
27	γ Cor. Aust.	...	18 59	37 13	1889·813	...	...	2·30	10	130	...	...	3
28	,,	...	,,	,,	1889·835	184·5	10	...	...	140	3 15 W	3 28 W	4
29	,,	...	,,	,,	1889·838	185·4	10	...	...	230	...	2 38 W	4
30	,,	6, 6	,,	,,	1889·849	186·9	10	...	...	230	2 51 W	3 1 W	4
31	,,	...	,,	,,	1889·849	185·0	10	...	...	140	4 18 W	4 44 W	4
32	,,	...	,,	,,	1890·531	182·8	10	...	...	300	3 33 E	3 16 E	3
33	,,	...	,,	,,	1890·531	...	...	1·62	5	300	3 16 E	3 2 E	3
34	,,	...	,,	,,	1890·534	182·8	10	...	...	300	2 27 E	2 14 E	3
35	,,	...	,,	,,	1890·550	185·6	10	...	...	300	3 9 E	2 51 E	3
36	,,	...	,,	,,	1890·550	...	...	1·63	10	170	2 20 E	2 6 E	4
37	,,	...	,,	,,	1890 600	...	...	1·64	10	170	2 12 E	2 0 E	3
38	,,	...	,,	,,	1890·709	180·7	10	...	...	170	2 12 W	2 28 W	...
39	,,	...	,,	,,	1890·709	...	...	1·54	10	...	2 39 W	3 1 W	...

Private Observatory, Windsor, New South Wales:
1891 *January* 16.

Observations of the Variable Star S. (10) *Sagittæ.* By J. E. Gore.

The following are my observations of this short-period variable during the year 1890. They form a continuation of the observations given in *Monthly Notices* for March 1890.

The comparison stars are as before :—

	Mag.
11 Sagittæ	5·8
D M + 16°, 4086	7·0

Date.	Dublin M.T. h	m	Mag.	Date.	Dublin M.T. h	m	Mag.
1890, Jan. 8	6	6	6·24	1890, Sept. 4	8	30 (?)	5·8
13	5	55	5·8	6	8	20	6·0
May 14	10	18	6·34	6	10	25	5·95
18	10	30	6·0	7	8	40	6·1
26	10	35	5·65	8	8	28	6·24
July 10	10	50	6·2	9	9	10	6·34
16	10	37	6·0	12	8	42	5·95
27	9	50	6·34	15	9	40	6·12
30	9	55	6·3	18	8	15	6·24
Aug. 5	10	35	6·16	22	10	0	5·8
6	9	20	6·4	27	10	14	6·23
7	9	25	6·48	28	7	15	6·2
8	10	15	6·2	Oct. 7	7	20	5·8
9	9	20	6·1	8	6	45	5·65
11	10	25	5·8	12	9	10	6·34
15	9	0	6·37	17	8	20	5·8
16	10	15	6·2	Nov. 7	6	50	6·28
17	9	12	6·0	8	10	15	6·04
25	9	20	6·0	11	8	15	5·8
28	9	10	5·8	12	7	58	5·73
29	9	0	5·95	15	6	25	6·33
30	9	10	6·1	Dec. 4	5	40	6·08
				29	6	30	6·13

Note on the Orbit of Juno. By A. M. W. Downing, M.A.

The following comparison of the observations of *Juno* made with the Transit Circle of the Royal Observatory, Greenwich, near the time of opposition in 1890, with (i.) the tabular places of the *Nautical Almanac*, and (ii.) with an ephemeris computed from the elements published in *Monthly Notices*, vol. l. p. 495, which the Astronomer Royal kindly permits me to publish, may be of interest.

Day, 1890.	Error of Tabular R.A. I.	Error of Tabular R.A. II.	Error of Tabular N.P.D. I.	Error of Tabular N.P.D. II.
	s	s	″	″
May 5	−4·08	+0·21	−5·64	+0·86
12	−3·99	+0·37	−7·08	−0·48
20	−4·24	+0·17	−6·01	+0·59
21	−4·31	+0·11	−5·82	−0·78
26	−4·39	+0·04	−5·05	−1·55
30	−4·28	+0·14	−5·62	+0·88
June 4	−4·40	+0·01	−8·19	−1·79
6	−4·49	−0·09	−4·71	+1·69
Mean ...	−4·27	+0·12	−6·02	−0·07

Blackheath:
March 1891.

Observations of the Planet Victoria and Comparison Stars made with the Transit Circle of the Radcliffe Observatory, Oxford, during the Opposition of 1889.

(*Communicated by E. J. Stone, M.A., F.R.S., Radcliffe Observer.*)

Observations of the Planet Victoria.

[The N.P.D.'s are corrected for Refraction but not for Parallax.]

Greenwich Mean Time of Observation. 1889.	h	m	s	Observer.	Observed Magnitude.	R.A. Apparent Places. h	m	s	N.P.D. °	′	″	Observer's Remarks.
June 25	13	46	42·4	F. B.	...	19	59	11·31	96	38	55·14	Very faint, hazy.
26	13	42	15·2	R.	9–8	19	58	39·91	96	31	24·23	
July 5	13	1	1·8	R.	8–9	19	52	48·77	95	33	35·32	
10	12	37	28·5	R.	8	19	48	54·37	95	9	59·63	Good.
18	11	59	21·1	F. B.	...	19	42	13·19	94	45	47·68	Very faint, bad definition; observed in dark field.
23	11	35	33·6	R.	8–9	19	38	4·55	94	39	23·76	
27	11	16	42·9	F. B.	...	19	34	56·99	94	38	51·48	Very faint, diffused.
29	11	7	23·6	W.	...	19	33	29·26	94	40	6·33	
Aug. 3	10	44	28·2	F. B.	...	19	30	12·90	94	47	0·87	
5	10	35	28·9	F. B.	8–9	19	29	5·24	94	51	11·99	
6	10	31	1·7	R.	...	19	28	33·82	94	53	34·07	
15	9	52	23·1	F. B.	9	19	25	17·87	95	21	46·48	Faint.
17	9	44	10·3	F. B.	9–10	19	24	56·84	95	29	24·01	Faint; observed in dark field.
29	8	57	56·9	F. B.	10–9	19	25	54·51	96	20	49·87	

Comparison Stars observed with Victoria. Separate Results.

Day.	Observer.	Obs. Mag.	Mean R.A. 1889 Jan. 1.	Mean N.P.D. 1889 Jan. 1.	Notes.
			Schön. Z. −6°, No. 5151.		
			h m s	° ′ ″	
June 25	F. B.		19 21 25·26	95 57 20·65	
July 15	R.		25·16	21·26	
19	R.		25·16	21·95	
			19 21 25·19	95 57 21·29	
			Schön. Z. −6°, No. 5158.		
June 26	R.	9–8	19 23 2·45	96 24 0·62	
July 10	R.	9–8	2·58	2·53	
18	F. B.	8–9	2·38	0·76	
		9–8	19 23 2·47	96 24 1·30	
			Schön. Z. −5°, No. 4985.		
July 5	R.	9–8	19 24 6·10	95 9 5·53	
Aug. 3	F. B.		6·24	6·23	
5	F. B.	9–8	6·35	6·31	
		9–8	19 24 6·23	95 9 6·02	
			Schön. Z. −5°, No. 4989.		
July 23	R.	9–8	19 25 17·97	95 54 13·46	
Aug. 30	W.		17·89	12·62	
Sept. 18	F. B.	8–9	17·86	13·62	
		9–8	19 25 17·91	95 54 13·23	
			Schön. Z. −5°, No. 4992.		
July 29	W.		19 25 40·35	95 21 4·31	
Sept. 10	R.		40·26	2·79	
25	R.		40·26	1·50	Very faint and bad image.
			19 25 40·29	95 21 2·87	
			Schön. Z. −5°, No. 5006.		
June 25	F. B.		19 27 50·39	94 58 48·47	
July 15	R.		50·47	49·39	
27	F. B.	8–7	50·43	48·86	
		8–7	19 27 50·43	94 58 48·91	

Day.	Observer.	Obs. Mag.	Mean R.A. 1889 Jan. 1.	Mean N.P.D. 1889 Jan. 1.	Notes.
			Schön. Z. −4°, No. 4843.		
			h m s	° ′ ″	
July 10	R.	9–8	19 28 37·63	94 41 24·21	
Aug. 26	F. B.		37·55	22·15	
Sept. 17	R.	9–8	37·63	22·63	
		9–8	19 28 37·60	94 41 23·00	
			Schön. Z. −4°, No. 4846.		
June 26	R.	8–9	19 29 20·73	94 33 5·45	
July 5	R.	8	20·74	5·23	
	R.		20·73	6·33	
		8	19 29 20·73	94 33 5·67	
			Schön. Z. −5°, No. 5021.		
Aug. 30	W.		19 30 41·15	95 1 3·89	A fainter star (Schön. Z. −5°, 5020) precedes about 15ˢ, and is 2 south.
Sept. 10	R.		41·13	3·48	
18	F. B.	8–7	41·15	2·81	
		8–7	19 30 41·14	95 1 3·39	
			Schön. Z. −4°, No. 4855.		
June 26	R.	8–7	19 30 53·38	94 32 43·63	
July 5	R.	8–7	53·25	43·09	
Sept. 13	R.		53·37	43·74	
		8–7	19 30 53·33	94 32 43·49	
			Schön. Z. −3°, No. 4649.		
Aug. 15	F. B.	8	19 31 22·12	93 43 19·57	
17	F. B.		22·21	18·24	
Sept. 25	R.		22·15	19·74	
		8	19 31 22·16	93 43 19·18	
			Schön. Z. −4°, No. 4861.		
Aug. 31	F. B.		19 31 53·88	94 53 40·34	
Sept. 9	W.		53·88	40·61	
Oct. 9	F. B.	5–6	53·98	41·46	
		5–6	19 31 53·91	94 53 40·80	
			Schön. Z. −5°, No. 5036.		
July 18	F. B.	7–6	19 34 26·79	95 42 7·40	
Aug. 26	F. B.		26·70	7·11	Bad definition.
29	F. B.	7	26·84	7·36	
		7–6	19 34 26·78	95 42 7·29	

Day.	Observer.	Obs. Mag.	Mean R.A. 1889 Jan. 1.	Mean N.P.D. 1889 Jan. 1.	Notes.
			Schön. Z. −4°, No. 4877.		
			h m s	° ′ ″	
Aug. 7	F. B.	8–7	19 34 53·52	94 17 21·28	
15	F. B.	8–7	53·35	20·84	
17	F. B.		53·55	21·14	
		8–7	19 34 53·47	94 17 21·09	
			Schön. Z. −4°, No. 4883.		
June 26	R.	8	19 35 56·00	94 32 49·36	
July 5	R.	8–7	55·88	48·91	Elongated image.
8	R.		56·10	49·64	
Sept. 13	R.		...	49·97	
		8–7	19 35 55·99	94 32 49·47	
			Schön. Z. −4°, No. 4903.		
June 25	F. B.		19 39 23·65	94 47 23·08	
26	R.	9	23·66	22·52	
Aug. 5	F. B.	8	23·68	22·18	
		8–9	19 39 23·66	94 47 22·59	
			Schön. Z. −4°, No. 4916.		
July 8	R.		19 40 59·42	93 55 61·36	
29	W.		59·47	61·71	
Aug. 15	F. B.	7–8	59·48	...	
Oct. 9	F. B.	7–8	59·53	59·87	
		7–8	19 40 59·48	93 55 60·98	
			Schön. Z. −5°, No. 5060.		
July 10	R.	8	19 41 53·34	95 30 24·25	
27	F. B.		53·22	23·05	
Aug. 7	F. B.	8–7	53·35	23·22	
		8	19 41 53·30	95 30 23·51	
			Schön. Z. −4°, No. 4926.		
June 25	F. B.		19 43 4·47	94 46 19·23	
26	R.	8–9	4·43	18·50	Mag. 8–7 on Aug. 5.
July 5	R.	8–7	4·40	17·39	Mag. 8 on Aug. 29.
18	F. B.		4·53	17·12	Mag. 8–7 on Sept. 18.
		8	19 43 4·46	94 46 18·06	

Day.	Observer.	Obs. Mag.	Mean R.A. 1889 Jan. 1.	Mean N.P.D. 1889 Jan. 1.	Notes.
			Schön. Z. – 4°, No. 4936.		
			h m s	° ′ ″	
June 26	R.	8	19 43 43·78	94 48 24·77	
July 5	R.	8–7	43·76	24·82	Mag. 8 on Aug. 29.
Aug. 5	F. B.	8–7	43·87	26·33	Mag. 8 on Sept. 18.
		8	19 43 43·80	94 48 25·31	
			Schön. Z. – 5°, No. 5075.		
July 29	W.		19 44 56·09	94 58 28·56	Mag. 7 on Aug. 29.
Aug. 3	F. B.		56·24	28·20	Mag. 7–6 on Sept. 18.
6	R.		56·21	27·91	
		7–6	19 44 56·18	94 58 28·22	
			Schön. Z. – 4°, No. 4960.		
July 23	R.	8	19 47 27·23	94 51 32·04	
Aug. 17	F. B.	8–7	27·17	31·80	
29	F. B.	8–9	27·17	33·01	Mag. 8–7 on Aug. 5.
		8	19 47 27·19	94 51 32·28	
			Schön. Z. – 5°, No. 5099.		
June 25	F. B.		19 48 22·31	95 20 0·36	
Aug. 28	W.		22·42	0·20	Mag. 8–7 on Aug. 5.
30	W.		22·35	1·75	
		8–7	19 48 22·36	95 20 0·77	
			Schön. Z. – 5°, No. 5120.		
June 26	R.	8–9	19 51 25·88	94 58 53·84	
July 29	W.		25·90	55·68	Mag. 8–9 on Aug. 5.
Aug. 15	F. B.	8–9	25·80	54·66	
		8–9	19 51 25·86	94 58 54·73	
			Schön. Z. – 5°, No. 5124.		
July 5	R.		19 52 3·41	95 28 59·19	Only one bisection in N.P.D.
Aug. 7	F. B.	9–8	3·52	59·51	
Sept. 6	R.		3·52	60 03	
		9–8	19 52 3·48	95 28 59·58	
			Schön. Z. – 6°, No. 5320.		
Aug. 6	R.		19 52 18·09	96 38 56·74	
26	W.		18·10	54·86	
Sept. 10	R.		18·11	56·52	
			19 52 18·10	96 38 56·04	

Day.	Observer.	Obs. Mag.	Mean R.A. 1889 Jan. 1.	Mean N.P.D. 1889 Jan. 1.	Notes.
			Schön. Z. −4°, No. 4984.		
			h m s	° ′ ″	
July 23	R	8	19 52 37·97	94 39 16·66	A fainter star (Sch. Z −4°, 4982) precedes 18ˢ, and of same N.P.D.
Aug. 17	F. B.	8	37·95	15·75	
Sept. 12	W.		38·04	16·83	Mag. 8–9 on Oct. 9.
		8	19 52 37·99	94 39 16·41	
			Schön. Z. −4°, No. 4992.		
July 10	R.	7–8	19 54 57·29	94 36 53·46	
Aug. 28	W.		57·28	52·37	
29	F. B.	7–8	57·34	53·02	
		7–8	19 54 57·30	94 36 52·95	
			Schön. Z. −6°, No. 5339.		
July 29	W.		19 55 39·76	96 40 50·54	
Aug. 30	W.		39·73	50·21	
Sept. 18	W.	8–9	39·79	49·18	
		8–9	19 55 39·76	96 40 49·98	
			Schön. Z. −5°, No. 5138.		
July 18	F. B.		19 56 17·67	95 17 47·82	Bad image.
27	F. B.	7–6	17·59	48·90	
Aug. 3	F. B.		17·62	49·20	
		7–6	19 56 17·63	95 17 48·64	
			Schön. Z. −8°, No. 5205.		
Aug. 7	F. B.	8–9	19 57 4·80	98 0 13·93	
Sept. 10	R.		4·82	15·77	
Oct. 12	R.		4·71	14·18	
		8–9	19 57 4·78	98 0 14·63	
			Schön. Z. −5°, No. 5144.		
Aug. 15	F. B.	8–9	19 57 21·65	94 56 28·48	
Sept. 6	R.		21·78	28·56	
		8–9	19 57 21·72	94 56 28·52	
			Schön. Z. −6°, No. 5360.		
July 23	R.	8–9	19 59 23·73	96 53 57·87	
Aug. 6	R.		23·78	58·06	
17	F. B.	8–9	23·71	56·37	
		8–9	19 59 23·74	96 53 57·43	

Day.	Observer.	Obs. Mag.	Mean R.A. 1889 Jan. 1.	Mean N.P.D. 1889 Jan. 1.	Notes.
			Schön. Z. −4°, No. 5016.		
			h m s	° ′ ″	
July 18	F. B.		20 0 44·77	94 44 3·35	
Aug. 30	W.		44·86	5·38	
Sept. 12	W.		44·77	3·81	
			20 0 44·80	94 44 4·18	
			Schön. Z. −7°, No. 5169.		
July 10	R.	7–8	20 0 46·73	97 19 57·08	
Aug. 7	F. B.	8	46·67	55·17	
28	W.		46·66	55·50	
29	F. B.	8	46·62	56·69	
		8–7	20 0 46·67	97 19 56·11	
			Schön. Z. −8°, No. 5237.		
July 29	W.		20 1 3·61	98 29 60·00	
Aug. 3	F. B.		3·65	59·62	
Sept. 13	R.		3·62	60·11	
			20 1 3·63	98 29 59·91	
			Schön. Z. −7°, No. 5183.		
June 26	R.	8	20 2 45·79	97 20 33·28	Mag. 8–7 on Aug. 15.
July 10	R.	7–8	45·73	34·38	Mag. 8–7 on Aug. 29.
		8–7	20 2 45·76	97 20 33·83	
			Schön. Z. −9°, No. 5382.		
July 5	R.	6–7	20 5 8·88	99 10 12·15	
23	R.	7–6	8·92	13·08	Mag. 6–7 on Aug. 15.
27	F. B.	6–7	8·75	12·50	
		6–7	20 5 8·85	99 10 12·58	

Mean Places of Comparison Stars observed with Victoria.

Star's Name.		Observed Mag.	Mean R.A. 1889, Jan. 1.	No. of Obs. in R.A.	Mean N.P.D. 1889 Jan. 1.	No. of Obs. in N.P.D.
	°		h m s		° ′ ″	
Schön Z.	−6·5151	...	19 21 25·19	3	95 57 21·29	3
	−6·5158	9–8	19 23 2·47	3	96 24 1·30	3
	−5·4985	9–8	19 24 6·23	3	95 9 6·02	3
	−5·4989	9–8	19 25 17·91	3	95 54 13·23	3
	−5·4992	...	19 25 40·29	3	95 21 2·87	3
	−5·5006	8–7	19 27 50·43	3	94 58 48·91	3
	−4·4843	9–8	19 28 37·60	3	94 41 23·00	3

Star's Name.	Observed Mag.	Mean R.A. 1889 Jan. 1.	No. of Obs. in R.A.	Mean N.P.D. 1889 Jan. 1.	No. of Obs. in N.P.D.
		h m s		° ′ ″	
Schön Z. −4°4846	8	19 29 20·73	3	94 33 5·67	3
−5·5021	8–7	19 30 41·14	3	95 1 3·39	3
−4·4855	8–7	19 30 53·33	3	94 32 43·49	3
−3·4649	8	19 31 22·16	3	93 43 19·18	3
−4·4861	5–6	19 31 53·91	3	94 53 40·80	3
−5·5036	7–6	19 34 26·78	3	95 42 7·29	3
−4·4877	8–7	19 34 53·47	3	94 17 21·09	3
−4·4883	8–7	19 35 55·99	3	94 32 49·47	4
−4·4903	8–9	19 39 23·66	3	94 47 22·59	3
−4·4916	7–8	19 40 59·48	4	93 56 0·98	3
−5·5060	8	19 41 53·30	3	95 30 23·51	3
−4·4926	8	19 43 4·46	4	94 46 18·06	4
−4·4936	8	19 43 43·80	3	94 48 25·31	3
−5·5075	7–6	19 44 56·18	3	94 58 28·22	3
−4·4960	8	19 47 27·19	3	94 51 32·28	3
−5·5099	8–7	19 48 22·36	3	95 20 0·77	3
−5·5120	8–9	19 51 25·86	3	94 58 54·73	3
−5·5124	9–8	19 52 3·48	3	95 28 59·58	3
−6·5320	...	19 52 18·10	3	96 38 56·04	3
−4·4984	8	19 52 37·99	3	94 39 16·41	3
−4·4992	7–8	19 54 57·30	3	94 36 52·95	3
−6·5339	8–9	19 55 39·76	3	96 40 49·98	3
−5·5138	7–6	19 56 17·63	3	95 17 48·64	3
−8·5205	8–9	19 57 4·78	3	98 0 14·63	3
−5·5144	8–9	19 57 21·72	2	94 56 28·52	2
−6·5360	8–9	19 59 23·74	3	96 53 57·43	3
−4·5016	...	20 0 44·80	3	94 44 4·18	3
−7·5169	8–7	20 0 46·67	4	97 19 56·11	4
−8·5237	...	20 1 3·63	3	98 29 59·91	3
−7·5183	8–7	20 2 45·76	2	97 20 33·83	2
−9·5382	6–7	20 5 8·85	3	99 10 12·58	3

Observers: W.—Mr. W. Wickham; R.—Mr. W. H. Robinson; F. B.—Mr. F. A. Bellamy.

Radcliffe Observatory, Oxford:
1890 *January* 21.

Mean Right Ascensions and North Polar Distances for January 1, 1889, *of Comparison Stars for the Planets Victoria and Sappho. Observed with the Cambridge Transit Circle.*

(*Communicated by Professor J. C. Adams.*)

Mean Right Ascensions and Mean North Polar Distances for January 1, 1889, *of Comparison Stars with the Planet Victoria. Observed with the Cambridge Transit Circle.*

No. of Star.	D.M.	Month and Date. 1889.	Mag.	Mean R.A. Jan. 1, 1889.	Mean N.P.D. Jan. 1, 1889.
	°			h m s	° ′ ″
1	−6–5151	June 25	7·7	19 21 25·277	95 57 22·38
		27		25·331	22·88
		July 5		25·277	21·47
2	−6–5158	June 26	8·3	19 23 2·638	96 24 1·49
		July 8		2·858	2·49
		11		2·537	2·46
3	−5–4985	June 25	8·5	19 24 6·228	95 9 7·85
		July 5	8·5	6·376	8·27
		Aug. 3	8·5	6·299	7·78
4	−5–4989	July 23	8·4	19 25 17·954	95 54 13·15
		Aug. 5	8·4	17·960	14·00
		6	8·4	17·933	14·01
		31	8·4	17·998	13·79
5	−5–4992	June 26	8·3	19 25 40·583	95 21 3·37
		July 11	8·2	40·391	4·08
		30	8·2	40·462	4·10
		Aug. 7	8·2	40·267	3·35
		Sept. 6	8·2	40·361	4·51
6	−5–5006	June 25	7·5	19 27 50·552	94 58 51·07
		July 8	7·6	50·627	51·26
		18	7·6	50·527	49·45
		Aug. 3	7·6	50·574	50·92
		Sept. 6	7·6	50·533	50·83
7	−4 4843	June 27		19 28 37·814	94 41 25·84
		July 11	8·5	37·677	25·00
		Sept. 7		37·797	24·39
8	−4–4846	July 5	7·7	19 29 20·712	94 33 7·02
		23	7·8	20·722	6·23
		Aug. 28	7·8	20·664	6·84

No. of Star.	D.M.	Month and Date. 1889.	Mag.	Mean R.A. Jan. 1, 1889.	Mean N.P.D. Jan. 1, 1889.
				h m s	° ′ ″
9	−5°5021	June 25	7·8	19 30 41·190	95 1 3·77
		July 8	7·8	41·248	2·77
		18	7·7	41·265	4·62
10	−4−4855	June 26	7·5	19 30 53·644	94 32 44·64
		Aug. 15		53·349	45·15
		31		53·463	44·79
11	−3−4649	July 5	8	19 31 22·045	93 43 20·29
		23	8	22·127	19·69
12	−4−4861	June 27	5	19 31 54·011	94 53 42·04
		July 11	5	53·970	41·03
		Aug. 6	5	54·107	41·14
		Sept. 6	5	53·996	42·62
13	−5−5036	June 25	6·8	19 34 26·921	95 42 8·71
		July 5		26·973	7·61
		Aug. 17		26·969	8·91
14	4−4877	June 26	7·5	19 34 53·740	94 17 22·40
		Aug. 3	7·5	53·569	22·83
		5	7·5	53·503	22·71
		15	7·5	53·445	22·55
		Sept. 6	7·5	53·528	23·08
15	−4−4883	June 27	9·3	19 35 56·163	94 32 51·76
		July 8		56·113	50·92
		11		56·046	50·98
		Aug. 6	7·7	56·058	50·73
		28	7·7	56·074	50·70
		29	7·7	56·032	50·90
		31	7·7	56·007	51·00
16	−4−4903	June 25	8·3	19 39 23·743	94 47 23·60
		July 5		23·780	24·13
		11		23·825	24·01
		Aug. 3		23·699	23·76
17	−4−4916	June 26	7·8	19 40 59·612	93 56 0·76
		July 30	7·8	59·554	1·53
		Aug. 15	7·8	59·475	1·70
		28	7·8	59·432	1·80
		Sept. 6	7·8	59·492	2·92

No. of Star.	D.M.	Month and Date. 1889.	Mag.	Mean R.A. Jan. 1, 1889.	Mean N.P.D. Jan. 1, 1889.
	°			h m s	° ′ ″
18	−5-5060	June 27	9·3	19 41 53·546	95 30 24·49
		Aug. 5	7·8	53·319	24·69
19	−4-4926	June 26	7·8	19 43 4·588	94 46 18·68
		July 11		4·559	19·69
		30		4·551	18·97
		Aug. 3		4·540	19·68
		6		4·569	18·87
		15		4·415	20·32
		29		4·499	18·79
		31		4·546	20·48
20	−4-4936	July 5	8	19 43 43·946	94 48 25·00
		Aug. 17		44·059	26·86
21	−5-5075	Aug. 5	6·5	19 44 56·186	94 58 28·19
		28		56·039	28·34
22	−4-4960	July 5	8	19 47 27·198	94 51 33·92
		18		27·377	33·95
		30		27·460	33·15
		Aug. 3		27·211	34·03
23	−5-5099	July 23	8	19 48 22·408	95 20 0·75
		Aug. 5		22·371	1·20
		6		22·425	1·87
		15		22·415	1·49
24	−5-5120	June 25	8·2	19 51 25·987	94 58 55·31
		Aug. 3		25·885	56·05
		28		25·823	55·41
		29		25·837	55·38
25	−5-5124	June 26	8·5	19 52 3·750	95 28 59·33
		July 23		3·456	59·85
		Aug. 15		3·583	60·55
		31		3·640	61·10
26	−6-5320	June 27		19 52 18·204	96 38 57·15
		Aug. 5	8·2	18·164	57·06
		17	8·2	18·318	58·21
		Sept. 6	8·2	18·124	57·44
27	−4-4984	July 11	8·2	19 52 38·194	94 39 18·21
		Aug. 6	8·2	38·020	18·68

No. of Star.	D.M.	Month and Date. 1889.	Mag.	Mean R.A. Jan. 1, 1889.	Mean N.P.D. Jan. 1, 1889.
				h m s	° ′ ″
28	−4°4992	June 25	7·8	19 54 57·323	94 36 54·01
		July 23		57·369	53·05
		Aug. 28		57·371	53·92
29	−6−5339	June 26	8·2	19 55 40·014	96 40 49·46
		July 11		39·856	49·82
		Aug. 5		39·707	51·09
0	−5−5138	July 5	6·3	19 56 17·713	95 17 50·33
		Aug. 3		17·687	50·13
		6		17·622	50·41
31	−8−5205	July 23	8·1	19 57 4·862	98 0 14·07
		Aug. 15		4·834	15·26
		31		4·719	14·96
32	−5−5144	July 11	8·2	19 57 21·802	94 56 29·58
		Aug. 5		21·727	29·65
		Sept. 6		21·719	30·23
33	−6−5360	July 5	8·3	19 59 23·962	96 53 58·89
		Aug. 3	8·5	23·854	59·50
		28	8·5	23·769	57·26
		29	8·5	23·781	57·97
34	−4−5016	July 18	7·2	20 0 44·997	94 44 5·41
		Aug. 5	7·2	44·839	5·83
35	−7−5169	July 11	8·2	20 0 46·700	97 19 56·54
		23		46·675	56·31
		Aug. 6		46·817	57·06
		15		46·699	56·48
		31		46·768	55·62
36	−8−5237	July 5	7·3	20 1 3·770	98 29 59·97
		Sept. 6		3·718	60·28
37	−9−5382	June 26	6·5	20 5 9·095	99 10 11·66
		27	7	8·939	12·15
		July 5	6·3	9·009	13·06
		18	6·5	8·945	13·62
		Aug. 6	6·5	8·967	13·48
		15	6·5	8·988	12·92
		28	6·5	8·975	13·21

Observations of Stars as Culminators.

D.M.	Month and Date. 1889.	Mag.	Mean R.A. Jan. 1, 1889.	Mean N.P.D. Jan. 1, 1889.
			h m s	° ′ ″
−8°4887	June 26	5·7	19 6 39·587	98 7 27·66
	27		39·491	26·84
	July 1		39·491	27·03
	5		39·349	28·36
	11		39·454	27·79
	18		39·401	27·69
	23		39·381	27·17
	30		39·468	28·06
	31		39·507	26·58
	Aug. 3		39·518	27·19
	5		39·381	26·97
	6		39·435	27·64
	7		39·423	27·58
	15		39·535	27·46
	17		39·541	28·11
	28		39·512	27·52
	29		39·384	28·87
	31		39·446	28·25
	Sept. 6		39·406	29·27
	7		39·424	28·23
−5-4936	June 27	5	19 14 37·282	95 37 22·26
	July 1		37·349	21·55
	5		37·319	21·47
	8		37·339	23·32
	11		37·329	21·54
	17		37·320	22·47
	18		37·376	22·46
	23		37·268	21·18
	30		37·424	22·43
	Aug. 3		37·370	22·37
	5		37·326	21·37
	6		37·301	22·44
	7		37·317	22·03
	15		37·439	21·84
	17		37·302	23·16

D.M.	Month and Date. 1889.	Mag.	Mean R.A. Jan. 1, 1889.	Mean N.P.D. Jan. 1, 1889.
			h m s	° ′ ″
−5–4936	Aug. 28		19 14 37·338	95 37 21·43
	29		37·326	22·81
	31		37·327	22·49
	Sept. 6		37·328	22·90
	7		37·361	21·72
−6–5451	June 27	6·3	20 14 31·559	96 42 28·39
	July 5		31·592	28·90
	11		31·489	28·95
	18		31·650	30·05
	23		31·414	29·83
	Aug. 28		31·379	29·65
	29		31·451	29·36
	31		31·467	29·48
	Sept. 6		31·522	29·65
−3–4888	July 5	6·3	20 19 55·077	93 9 36·79
	8		55·185	36·63
	11		55·091	36·18
	23		55·063	36·62
	Aug. 28		55·058	36·29
	29		55·114	35·77
	31		55·059	36·29
	Sept. 6		55·055	36·67

Mean Right Ascensions and Mean North Polar Distances for January 1, 1889, *of Comparison Stars with the Planet Sappho. Observed with the Cambridge Transit Circle.*

No. of Star.	D.M.	Month and Date. 1889.	Mag.	Mean R.A. Jan. 1, 1889.	Mean N.P.D. Jan. 1, 1889.
				h m s	° ′ ″
	+ 8–101	Sept. 10	8·5	0 37 16·297	81 35 28·90
	+ 7–104	10	8	0 39 55·566	82 45 45·00
1	+ 8–110	16	7·7	0 42 25·240	81 23 2·80
		20		25·270	2·87
		Oct. 3		25·230	1·44
		7		25·196	3·30
2	+ 9 [illegible]90	Sept. 17	9	0 42 31·166	80 20 50·19
		25	9	1·110	49·92

No. of Star.	D.M.	Month and Date. 1889.	Mag.	Mean R.A. Jan. 1, 1889.	Mean N.P.D. Jan. 1, 1889.
				h m s	° ′ ″
3	+11–102	Sept. 18	8·6	0 44 24·341	78 46 23·79
		Oct. 3		24·409	24·68
		9		24·376	24·08
4	+ 9–097	Sept. 10	8·5	0 44 46·651	80 11 35·82
		20		46·784	35·36
		25		46·779	36·34
		Oct. 7		46·645	35·36
		12		46·623	35·79
		21		46·701	35·19
5	+11–106	Sept. 16	7	0 45 46·211	77 49 6·96
		Oct. 8		46·078	6·98
		10		46·172	7·30
6	+ 9–099	Sept. 17	8·3	0 46 20·497	80 0 8·65
		Oct. 9		20·399	6·10
7	+12–104	Sept. 20	7·3	0 46 40·018	76 57 14·75
		25		40·103	15·79
		Oct. 3		40·130	15·69
8	+ 9–101	Sept. 10	8·3	0 47 0·585	80 47 55·73
		18		0·631	54·61
		Oct. 12		0·576	56·44
9	+10–105	Oct. 7	8·4	0 48 2·888	79 28 48·63
		8		2·865	48·00
		9		2·840	46·62
		10		2·974	47·54
		14		2·998	47·59
10	+12–108	Sept. 10	8·2	0 49 11·918	77 45 15·41
		16		12·045	14·05
		20		11·932	15·63
		Oct. 3		12·118	14·66
11	+13–129	Sept. 17	6·5	0 50 19·780	76 38 58·88
		25		19·760	57·78
		Oct. 7		19·673	57·61
12	+11–118	Sept. 18	8·8	0 50 40·430	77 53 15·07
		Oct. 9		40·523	14·62

No. of Star.	D.M.	Month and Date. 1889.	Mag.	Mean R.A. Jan. 1, 1889.	Mean N.P.D. Jan. 1, 1889.
	°			h m s	° ′ ″
13	+13–130	Oct. 8	8·7	0 50 52·305	75 49 29·51
		10		52·342	30·08
14	+ 9–110	Oct. 12	8·7	0·50 59·096	80 35 4·24
		21		59·228	6·36
		31		59·396	4·39
15	+11–120	Sept. 10	8·2	0 51 32·776	78 10 14·49
		20		32·901	13·82
		Oct. 3		32·997	13·06
16	+12–119	Sept. 16	6	0 52 5·148	76 54 14·06
		Oct. 7		4·967	16·66
		24		5·044	16·33
		25		5·095	15·64
17	+13–143	Sept. 10	8·5	0 53 53·646	75 59 20·58
		18		53·883	21·14
		Oct. 3		53·684	21·94
18	+10–115	Sept. 16	8·2	0 55 25·630	79 24 59·98
		25		25·648	61·11
19	+11–135	Sept. 20	8	0 55 32·916	78 41 9·15
		Oct. 14		32·826	9·80
		21		32·831	9·40
		25		32·810	9·87
20	+13–150	Sept. 17	8·5	0 56 43·529	79 20 42·89
		Oct. 3	8·5	43·560	40·92
		24		43·565	43·77
		31		43·539	40·39
21	+15–154	Sept. 18	8·5	0 57 9·577	74 27 33·08
		Oct. 10		9·849	33·94
		12		9·605	32·29
22	+12–126	Sept. 20	7·8	0 57 16·380	77 32 49·48
		25		16·454	49·90
23	+13–155	Sept. 16	8·7	0 58 0·654	76 39 32·31
		Oct. 9		0·682	32·50
24	+14–163	Sept. 10	5·5	0 59 13·705	75 39 4·18
		17		13·763	4·76
		25		13·753	4·14

No. of Star.	D.M.	Month and Date. 1889.	Mag.	Mean R.A. Jan. 1, 1889.	Mean N.P.D. Jan. 1, 1889.
				h m s	° ′ ″
24	+14–163	Oct. 8	5·5	0 59 13·681	75 39 4·04
		12		13·933	3·77
		25		13·770	4·92
25	+14–168	Sept. 18	9	0 59 57·018	75 36 42·56
		20		57·076	44·10
		Oct. 9		57·127	44·09
		10		57·131	44·48
		24		57·087	45·12
26	+15–159	Sept. 16	8·5	1 0 29·723	74 16 49·53
		Oct. 31		29·670	48·91
27	+15–164	Sept. 11	8	1 1 59·509	74 43 45·28
		17		59·562	45·72
		20		59·503	44·83
		25		59·545	45·23
		Oct. 7		59·398	45·25
		14		59·475	44·32
28	+16–116	Sept. 18	8	1 2 2·013	73 10 47·71
		Oct. 8		2·215	49·11
		25		2·232	51·11
29	+16–119	Sept. 16	8·6	1 2 34·968	72 56 18·96
		Oct. 9		34·960	19·34
		10		34·924	20·20
		24		35·025	20·31
30	+14–175	Sept. 17	6·4	1 4 18·272	74 55 1·40
		18		18·158	55 0·78
		Oct. 3		18·287	54 59·84
		25		18·269	55 2·11
31	+17–166	Sept. 10	8·8	1 5 3·748	72 11 53·66
		16		3·999	53·32
		Oct. 9		3·904	54·55
32	+16–123	Oct. 7	8·5	1 5 10·297	73 48 48·68
		10		10·443	47·43
		14		10·220	47·71

No. of Star.	D.M.	Month and Date. 1889.		Mag.	Mean R.A. Jan. 1, 1889.	Mean N.P.D. Jan. 1, 1889.
	°				h m s	° ′ ″
33	+13–175	Oct.	8	8·2	1 5 24·071	75 53 55·36
			24		24·111	55·49
			31		24·164	52·74
34	+15–175	Sept.	10	8·3	1 6 55·791	73 49 31·16
		Oct.	9	8·5	55·862	30·78
			25	8·5	55·780	32·39
35	+15–177	Sept.	25	6·5	1 8 13·818	74 27 14·87
		Oct.	3		13·836	15·10
			7		13·776	15·87
			10		13·743	14·28
			14		13·707	14·25
			24		13·916	15·61
			31		13·875	13·76
36	+16–129	Oct.	3	8·3	1 10 15·814	72 57 6·72
			7		15·796	7·07
			8		15·756	6·29
			9		15·876	7·62
			24		15·945	7·69
			25		15·695	8·32
37	+15–185	Sept.	18	8·8	1 11 34·372	74 13 52·20
			20		34·567	51·17
			25		34·386	52·63
		Oct.	10		34·566	52·30
			31		34·496	52·09
38	+17–183	Sept.	17	8	1 12 26·053	72 0 29·15
		Oct.	3		26·221	29·27
			7		26·086	28·61
			8		26·089	28·38
			9		26·024	29·05
			14		26·001	27·45
			24		26·167	28·69
			25		25·976	29·30

Observations of Stars as Culminators.

D.M.	Month and Date. 1889.	Mag.	Mean R.A. Jan. 1, 1889.	Mean N.P.D. Jan. 1, 1889.
			h m s	° ′ ″
+10°065	Sept. 16	7·3	0 31 32·082	79 10 27·26
	17		31·985	28·80
	18		31·858	27·49
	20		32·091	28·96
	25		31·967	28·50
	Oct. 3		31·906	26·68
	7		31·964	28·41
	8		31·989	28·41
	9		32·038	27·51
	10		32·168	29·28
	12		32·091	28·33
	14		32·247	26·17
	21		32·023	28·32
	4		31·978	30·50
	25		31·966	28·37
	31		32·083	27·02
+15-106	Sept. 16	7·3	0 37 4·373	73 56 35·49
	17		4·261	38·95
	18		4·134	36·40
	20		4·323	36·64
	25		4·281	37·13
	Oct. 3		4·141	36·50
	7		4·239	37·25
	8		4·277	36·75
	9		4·334	36·31
	10		4·284	37·21
	12		4·231	36·54
	14		4·363	34·96
	21		4·278	37·40
	24		4·301	37·88
	25		4·254	36·63
	31		4·432	36·50
+10-171	Sept. 16	7	1 17 2·176	79 12 45·99
	17		2·179	47·63
	18		2·101	46·22
	20		2·255	46·99
	25		2·201	47·26

D.M.	Month and Date. 1889.		Mag.	Mean R.A. Jan. 1, 1889. h m s	Mean N.P.D. Jan. 1, 1889. ° ′ ″
+10°171	Oct.	3	7	1 17 2·300	79 12 47·22
		7		2·121	47·14
		8		2·166	46·56
		9		2·215	47·84
		10		2·217	46·47
		14		2·175	46·55
		24		2·291	48·32
		25		2·083	47·85
		31		2·222	46·80
+16–154	Sept.	16	7·2	1 22 26·012	73 29 42·55
		17		25·922	44·25
		18		25·907	43·26
		20		26·057	43·54
		25		26·085	43·84
	Oct.	3		25·934	44·44
		7		25·965	44·17
		8		25·925	43·86
		9		25·958	44·52
		10		25·989	43·96
		14		26·000	43·74
		24		26·139	44·87
		25		25·873	44·83
		31		26·151	43·56

Observations of the Satellites of Saturn: Conjunctions with the centre of the planet; of Occultations of Stars by the Moon; and of Phenomena of Jupiter's Satellites. Observed at Mr. E. Crossley's Observatory, Bermerside, Halifax, with the 9½-inch Cooke Refractor. Power 240. By J. Gledhill.

1886, January 11.—Very faint. *Enceladus* s. Not up at $8^h\ 50^m$. Up at $8^h\ 55^m$ (?) Past at $9^h\ 5^m$ (?). Certainly past at $9^h\ 10^m$. G.M.T.

January 18.—*Tethys* s. Not up at $8^h\ 50^m$ and $8^h\ 55^m$. Past at $9^h\ 10^m$.

January 26.—*Rhea.* Up at $5^h\ 50^m$ (?), $5^h\ 55^m$ (?), 6^h (?). Past at $6^h\ 5^m$. *Enceladus* s. Very difficult owing to haze. $10^h\ 30^m$ not in line. $10^h\ 45^m$ past.

February 2.—*Enceladus* s. Not in line at $6^h\ 45^m$. Clouds passing. Not up at $6^h\ 50^m$. Past at $7^h\ 5^m$.

February 3.—*Tethys* n. Not in line at 10^h. Past at $10^h\ 9^m$. Good definition.

February 4.—Good sky. *Enceladus* not seen. *Rhea* s. On line about $6^h\ 37^m$. *Dione* s. Up at $7^h\ 49^m$. *Tethys* s. Up at $8^h\ 42^m$.

December 2 (with the 3-foot reflector).—*Dione* s. 13^h not in line, nor at $13^h\ 2^m$; probably in line between $13^h\ 3^m$ and $13^h\ 7^m$. Past at $13^h\ 10^m$. *Mimas*. Looked long and carefully for *Mimas*; saw it steadily at $13^h\ 3^m$. *Tethys* n. Not up at $13^h\ 45^m$ and $13^h\ 50^m$; up between $13^h\ 53^m$, $13^h\ 57^m$. Past at 14^h.

December 4 (3-foot reflector).—*Mimas* not seen. *Tethys* n. Up at $11^h\ 3^m$ and past at $11^h\ 10^m$. (Mr. Crossley at telescope.)

December 20.—*Dione* n. Not up at $7^h\ 40^m$, nor at $7^h\ 42^m$. Doubtful from $7^h\ 45^m$ to $7^h\ 47^m$. Past at $7^h\ 50^m$ (?) Past at $7^h\ 51^m$.

1887, January 12.—*Dione* s. Not in line at $13^h\ 40^m$. Doubtful from $13^h\ 45^m$ to $13^h\ 50^m$. Past at $13^h\ 52^m$. Bad sky.

January 26.—*Tethys* n. Not in line at $7^h\ 5^m$. Up from $7^h\ 10^m$ to $7^h\ 15^m$. Past at $7^h\ 17^m$. *Dione* s. Not in line before $7^h\ 50^m$. Up between $7^h\ 55^m$ and 8^h. Past at $8^h\ 2^m$ (?) Past at $8^h\ 4^m$.

January 30.—*Dione* n. Not up at $8^h\ 20^m$. Up between $8^h\ 27^m$ and $8^h\ 33^m$. Past at $8^h\ 35^m$.

February 5.—*Rhea* s. Not in line before $9^h\ 23^m$. Probably up between $9^h\ 25^m$ and $9^h\ 30^m$. Past at $9^h\ 33^m$.

February 10.—*Dione* n. Up between $6^h\ 57^m$ and $7^h\ 5^m$. Past at $7^h\ 7^m$ (?). Certainly past at $7^h\ 10^m$. *Tethys* n. Not up at $9^h\ 27^m$. Probably up between $9^h\ 30^m$ and $9^h\ 35^m$.

February 11.—*Tethys* s. Not in line at 8^h. In line between $8^h\ 5^m$ and $8^h\ 10^m$. Past at $8^h\ 17^m$. The satellite unusually bright. *Enceladus* also was very well seen.

February 12.—*Tethys* n. Not up at $6^h\ 45^m$. Up between $6^h\ 50^m$ and $6^h\ 55^m$. Past at $7^h\ 3^m$.

February 14.—*Dione* s. Not on line at $9^h\ 30^m$. Probably so between $9^h\ 32^m$ and $9^h\ 40^m$. Past at $9^h\ 45^m$. *Rhea* s. Up between $10^h\ 10^m$ and $10^h\ 15^m$. Past at $10^h\ 20^m$.

February 18.—*Dione* n. Not on line at $11^h\ 50^m$. On between $11^h\ 52^m$ and $12^h\ 5^m$. Past at $12^h\ 12^m$ (?).

February 26.—*Tethys* s. Not up at $10^h\ 25^m$. Up between $10^h\ 32^m$ and $10^h\ 40^m$. Past at $10^h\ 42^m$ (?).

February 27.—*Tethys* n. Not on line at $9^h\ 10^m$. On between $9^h\ 15^m$ and $9^h\ 20^m$.

March 29.—*Rhea* n. Not up at $7^h\ 53^m$. On line between $7^h\ 55^m$ and $8^h\ 5^m$. Past at $8^h\ 10^m$.

March 31.—*Tethys* n. Not up at $11^h\ 15^m$. Up between $11^h\ 20^m$ and $11^h\ 25^m$. Past at $11^h\ 30^m$.

April 1.—*Tethys* s. Not on line at $10^h\ 5^m$. On between $10^h\ 7^m$ and $10^h\ 12^m$. Past at $10^h\ 15^m$.

April 2.—*Tethys* n. On line between $8^h\ 50^m$ and $8^h\ 55^m$. Past at 9^h.

April 16.—*Rhea* n. Not up at $9^h\ 50^m$. Up between $9^h\ 55^m$ and $10^h\ 5^m$. Past at $10^h\ 10^m$.

April 17.—*Tethys* n. On line between $11^h\ 20^m$ and $11^h\ 25^m$. *Saturn* very low; satellite not well seen.

April 18.—*Dione* s. On line between $8^h\ 27^m$ and $8^h\ 37^m$. Not well seen.

Tethys s. Judged on line between $9^h\ 57^m$ and $10^h\ 6^m$. Bad sky.

April 19.—*Tethys* n. In conjunction between $8^h\ 40^m$ and $8^h\ 50^m$. Planet low.

1890, March 29.—*Rhea* s. Not up at $8^h\ 35^m$. Past at $8^h\ 43^m$.

March 30.—*Enceladus* not seen.

April 2.—*Dione* n. Not up at $8^h\ 55^m$. Past at $9^h\ 3^m$.

Tethys in contact with the ball about 9^h (?). Uncertain.

April 3.—*Tethys* disappeared at the ball about $8^h\ 50^m$.

April 4.—*Tethys*. Saw it well at $7^h\ 30^m$ and $7^h\ 40^m$ moving up to the ball. Could not see it at 8^h.

April 7.—*Rhea* s. Not up at $9^h\ 15^m$. Past at $9^h\ 20^m$. Could not see *Enceladus* for some time. In conjunction, east, between $12^h\ 45^m$ and $12^h\ 50^m$.

April 8.—Watched for the conjunction of *Dione* and *Japetus*. Clouds prevented observation, but saw the satellites $10''\pm$ apart about 9^h.

May 13.—*Dione* n. In conjunction about $10^h\ 15^m$

Occultations of stars by the Moon observed with the $9\frac{1}{3}$-inch Cooke refractor. Power 240 :—

1887, February 6.—3 *Cancri*. Disappearance $9^h\ 16^m\ 32^s$, G.M.T.

April 2.—B.A.C. 2,731. Disappearance $9^h\ 15^m\ 12^s$, G.M.T.

October 24.—θ *Capricorni*. Reappearance $5^h\ 51^m\ 31^s$, G.M.T.

October 28.—B.A.C. 81. Disappearance $11^h\ 24^m\ 7^s$, G.M.T.

1888, October 13. 20 *Capricorni*. Disappearance $7^h\ 7^m\ 15^s$, G.M.T.

1889, January 18.—θ *Libræ*. Disappearance $10^h\ 50^m\ 28^s$, G.M.T.

February 9.—*i Tauri*. Disappearance $6^h\ 48^m\ 41^s$, G.M.T. Reappearance $7^h\ 56^m\ 39^s$, G.M.T.

February 12.—63 *Geminorum*. Disappearance $7^h\ 47^m\ 49^s$, G.M.T.

1890, April 30.—ν *Virginis*. Disappearance $11^h\ 53^m\ 27^s$, G.M.T.

August 28.—37 *Capricorni*. Disappearance $11^h\ 19^m\ 14^s$, G.M.T.

Phenomena of Jupiter's Satellites observed with the 9½-inch Cooke Refractor.

1885.	Satellite.	Phenomena.		G.M.T. h m s	Remarks.
Apr. 5	I.	Tr. I.	First contact	9 33	Much cloud.
	I.	Sh. I.	Just within	10 34	Much cloud.
17	II.	Sh. I.	Bisection	8 21	Good sky.
			Inner contact	8 23	
	II.	Tr. E.	Inner contact	8 57	
			Bisection	8 59½	
			Outer contact	9 0	
	II.	Sh. E.	Inner contact	11 14	Not well seen.
18	III.	Sh. E.	Inner contact	8 35	
			Just off	8 37	
	IV.	Tr. E.	Inner contact	11 30	Satellite like a dark spot from 7 P.M. till egress.
25	III.	Sh. I.	Just within	9 4	Shadow looked small and dark. At 9.30 it was dark and larger.
26	II.	Ec. R.	First seen	8 59 23	Full brightness, $9^h\ 4^m$.
27	IV.	Ec. R.	First seen	8 35 39	
May 2	III.	Tr.	Ingress not seen		The satellite was dark during transit, but not black.
6	I.	Oc. D.	First contact	8 31	
13	IV.	Oc. D.	First contact	9 27	Fair definition.
			Bisection	9 29	
			Just gone	10 1	
	I.	Oc. D.	First contact	10 24	
			Bisection	10 26	
			Disappeared	10 28½	
	III.	Ec. R.	First seen	10 37 7	Full brightness, $10^h\ 41^m \pm$.
14	I.	Tr. E.	Inner contact	10 5	
			Half off	10 7	
			Outer contact	10 9	
20	III.	Oc. R.	First seen	9 30	Definition not good.
			Just off	9 32½	
	III.	Ec. D.	Fading	11 10	
			Half gone	11 12	
			Last seen	11 15	Or $11^h\ 14^m\ 46^s$.
26	II.	Sh. I.	Bisection	10 43½	Clouds pass. Planet low. Mr. Crossley at telescope.
			Just within	10 44½	
	II.	Tr. E.	Just off	10 6	Planet low.

	Satellite.	Phenomena.	G.M.T. h m s	Remarks.
1885.				
May 30	IV.	Oc. R. First seen	8 55	Very bad sky.
		Just off	8 57	
	I.	Sh. E. Inner contact	9 37	
June 2	II.	Tr. I. First contact	9 47	Cloudy.
1886.				
Apr. 2	II.	Oc. D. First contact	9 19	Clouds pass.
4	III.	Tr. E. Outer contact	9 21	
9	I.	Oc. D. Outer contact	10 4	Good sky.
		Just gone	10 6	Transit of red spot, $10^h\ 15^m$.
	II.	Oc. D. Outer contact	11 37	
		Bisection	11 39	
		Just gone	11 41	
11	II.	Tr. E. Inner contact	8 45	Satellite invisible, mostly, during transit.
		Bisection	8 47	
		Outer contact	8 49	
	II.	Sh. E. Inner contact	9 46	
	III.	Tr. I. First contact	9 49	At $10^h\ 30^m$ the satellite was quite dark on the disc.
		Bisection	9 53	
		Inner contact	9 56	
May 18	I.	Ec. R. First seen	11 13 18	
1889.				
Aug. 22	III.	Oc. R. First seen	7 55½	Planet very low.
	I.	Sh. I. Just within	8 15½	
28	II.	Ec. R. First seen	9 18 31	Planet very low.
		Half out	9 20	
		Full	9 22	
29	III.	Oc. D. Outer contact	8 43	
		Half gone	8 46	
		Just gone	8 48½	
	I.	Tr. I. First contact	8 55	
		Bisection	8 56½	
		Inner contact	8 59	
Sept. 6	I.	Oc. D. First contact	8 9	Planet very low; bad definition.
		Disappeared	8 13	
7	I.	Tr. E. Inner contact	7 34½	Very bad definition.
		Just off	7 38	
1890.				
Sept. 7	II.	Sh. E. Last seen	8 58	
27	I.	Ec. R. First seen	7 38 59	Bad sky.

Ephemeris for Physical Observations of Jupiter, 1891. By A. Marth.

Greenwich Noon	Angle of Position of ♃'s Axis. P	L−O.	Diff.	B	Corr. of log. Δ.	Light-time.	Δ−O.	β	Longitude of ♃'s Central Meridian. (877°·90) I.	(870°·27) II.	Corr. for Phase.	Apparent Diameter. Equat.	Phase.	Polar.
1891.	°	°		°		m	°	°	°	°	°	″	″	″
April 17	335·765	203·513	391	+1·005	−165	46·736	194·9068	+0·7930	216·99	32·64	+0·32	34·81	0·20	32·59
19	·714	203·904	386	1·026	168	46·540	195·0857	·8022	172·52	332·91	·34	34·95	·21	32·73
21	·665	204·290	380	1·046	171	46·339	195·2646	·8115	128·06	273·19	·36	35·10	·22	32·87
23	·618	204·670	374	1·067	174	46·133	195·4435	·8207	83·61	213·47	·37	35·26	·23	33·02
25	·572	205·044	368	1·087	177	45·924	195·6225	·8300	39·16	153·76	·39	35·42	·24	33·17
27	335·528	205·412	361	+1·108	−179	45·710	195·8015	+0·8392	354·72	94·06	+0·40	35·59	·25	33·32
29	·486	205·773	354	1·128	182	45·493	195·9805	·8484	310·29	34·37	·42	35·76	·26	33·48
May 1	·445	206·127	348	1·148	184	45·271	196·1596	·8576	265·87	334·69	·43	35·93	·27	33·64
3	·406	206·475	340	1·168	186	45·046	196·3387	·8669	221·46	275·02	·45	36·11	·28	33·81
5	·369	206·815	332	1·188	188	44·818	196·5178	·8761	177·06	215·36	·46	36·29	·29	33·98
7	335·333	207·147	325	+1·207	−190	44·586	196·6970	+0·8853	132·67	155·71	+0·48	36·48	·30	34·16
9	·299	207·472	318	1·227	191	44·351	196·8763	·8945	88·29	96·06	·49	36·68	·31	34·34
11	·266	207·790	309	1·246	192	44·113	197·0556	·9036	43·92	36·43	·50	36·88	·32	34·53
13	·235	208·099	301	1·265	194	43·872	197·2349	·9128	359·56	336·81	·51	37·08	·33	34·72
15	·206	208·400	292	1·284	195	43·629	197·4142	·9220	315·20	277·19	·53	37·28	·34	34·91
17	335·178	208·692	283	+1·303	−195	43·383	197·5935	+0·9311	270·86	217·59	+0·54	37·49	·35	35·11
19	·151	208·975	275	1·322	196	43·135	197·7729	·9403	226·53	158·00	·55	37·71	·36	35·31

Greenwich Noon 1891.		Angle of Position of ♃'s Axis. P	L−O.	Diff.	B	Corr. of log. Δ.	Light-time.	Δ−O.	β	Longitude of ♃'s Central Meridian. (877°·90) I.	(870°·27) II.	Corr. for Phase.	Apparent Diameter. Equat.	Phase.	Polar.
		°	°		°		m	°	°	°	°	°	″	″	″
May	21	335·125	209·250	266	+1·340	−196	42·885	197·9523	+0·9494	182·20	98·42	+0·56	37·93	0·37	35·52
	23	·101	209·516	256	1·358	197	42·633	198·1318	·9586	137·89	38·84	·57	38·15	·38	35·73
	25	·078	209·772	246	1·376	197	42·380	198·3113	·9677	93·59	339·28	·57	38·38	·38	35·94
	27	335·056	210·018	237	+1·394	−197	42·125	198·4908	+0·9768	49·30	279·72	+0·58	38·61	·39	36·16
	29	·036	210·255	227	1·412	196	41·869	198·6704	0·9860	5·02	220·18	·58	38·85	·40	36·38
	31	335·017	210·482	217	1·429	196	41·612	198·8500	0·9951	320·75	160·65	·59	39·09	·40	36·60
June	2	334·999	210·699	206	1·446	195	41·354	199·0296	1·0042	276·49	101·13	·59	39·33	·41	36·83
	4	·983	210·905	196	1·463	194	41·096	199·2093	1·0132	232·24	41·62	·59	39·58	·41	37·06
	6	334·967	211·101	185	+1·479	−193	40·837	199·3890	+1·0223	188·00	342·12	+0·59	39·83	·41	37·30
	8	·953	211·286	173	1·495	192	40·578	199·5687	1·0314	143·78	282·63	·59	40·09	·42	37·54
	10	·939	211·459	162	1·511	191	40·319	199·7485	1·0405	99·57	223·16	·59	40·34	·42	37·78
	12	·927	211·621	151	1·526	189	40·061	199·9283	1·0496	55·36	163·69	59	40·60	·42	38·02
	14	·916	211·772	139	1·541	188	39·803	200·1081	1·0586	11·16	104·23	·59	40·87	·42	38·27
	16	334·906	211·911	127	+1·556	−186	39·546	200·2880	+1·0677	326·98	44·79	+0·59	41·13	·42	38·52
	18	·896	212·038	115	1·571	184	39·280	200·4679	1·0767	282·81	345·36	·58	41·40	·42	38·77
	20	·888	·153	103	1·585	182	39·036	200·6478	1·0857	238·65	285·94	·58	41·67	·42	39·02
	22	·880	·256	91	1·599	179	38·784	200·8278	1·0947	194·50	226·53	·57	41·94	·42	39·27
	24	·873	·347	79	1·612	177	38·533	201·0078	1·1037	150·36	167·13	·56	42·21	·41	39·53
	26	334·867	212·426	66	+1·625	−174	38·284	201·1878	+1·1127	106·23	107·74	+0·55	42·49	·41	39·78

Greenwich Noon		Angle of Position of ♃'s Axis. P	L−O.	Diff.	B	Corr. of log. Δ.	Light-time.	A−O.	β	Longitude of ♃'s Central Meridian. (877°·90) I.	(870°·27) II.	Corr. for Phase.	Apparent Diameter. Equat.	Phase.	Polar.
1891.			°		°		m	°	°	°	°	°	″	″	″
June	28	334·863	212·492	53	+1·637	−171	38·038	201·3679	+1·1217	62·12	48·36	+0·54	42·76	0·40	40·04
	30	·859	·545	40	1·649	168	37·794	201·5480	1·1307	18·02	348·99	·53	43·04	·40	40·30
July	2	·856	·585	27	1·661	165	37·554	201·7281	1·1397	333·92	289·64	·52	43·32	·39	40·56
	4	·853	·612	15	1·672	162	37·316	201·9083	1·1486	289·84	230·30	·50	43·59	·38	40·82
	6	334·852	212·627	1	+1·683	−158	37·082	202·0885	+1·1576	245·77	170·96	+0·48	43·87	·37	41·08
	8	·852	·628	12	1·693	155	36·852	202·2687	1·1666	201·71	111·64	·47	44·14	·36	41·33
	10	·852	·616	25	1·703	151	36·626	202·4490	1·1755	157·66	52·33	·45	44·41	·35	41·59
	12	·853	·591	38	1·712	147	36·404	202·6293	1·1844	113·62	353·03	·43	44·68	·34	41·84
	14	·855	·553	51	1·720	143	36·187	202·8096	1·1933	69·59	293·74	·41	44·95	·32	42·09
	16	334·858	212·502	63	+1·728	−139	35·975	202·9900	+1·2022	25·57	234·46	+0·39	45·22	·31	42·34
	18	·862	·439	76	1·736	135	35·768	203·1704	1·2111	341·55	175·18	·37	45·48	·30	41·58
	20	·866	·363	89	1·743	130	35·567	203·3508	1·2200	297·55	115 92	·35	45·74	·28	42·82
	22	·871	·274	101	1·749	126	35·372	203·5312	1·2288	253·56	56·67	·33	45·99	·27	43·06
	24	·878	·173	113	1·755	121	35·182	203·7117	1·2377	209·58	357·43	·31	46·24	·25	43·29
	26	334·886	212·060	126	+1·760	−116	34·999	203·8922	+1·2465	165·60	298·19	+0·29	46·48	·24	43·52
	28	·894	211·934	137	1·765	111	34·822	204·0727	1·2554	121·64	238·96	·27	46·71	·22	43·74
	30	·903	211·797	149	1·769	106	34·652	204·2533	1·2642	77·68	179·74	·25	46·94	·20	43·96
Aug.	1	·913	211·648	160	1·772	101	34·489	204·4339	1·2730	33·73	120·53	·23	47·16	·19	44·16
	3	·925	211·488	171	1·775	96	34·334	204·6145	1·2818	349·78	61·32	·21	47·38	·17	44·36

Greenwich Noon 1891.		Angle of Position of ♃'s Axis. P	L−O.	Diff.	B	Corr. of log. Δ.	Light-time.	Δ−O.	β	Longitude of ♃'s Central Meridian. (877°·90) I.	(870°·27) II.	Corr. for Phase.	Apparent Diameter. Equat.	Phase.	Polar.
		°	°		°		m	°	°	°	°	°	″	″	″
Aug.	5	334·937	211·317	182	+1·777	− 91	34·186	204·7951	+1·2906	305·84	2·12	+0·19	47·58	0·15	44·55
	7	·950	211·135	191	1·778	86	34·046	204·9758	1·2994	261·91	302·93	·17	47·78	·14	44·74
	9	·964	210·944	201	1·779	80	33·914	205·1565	1·3081	217·98	243·74	·15	47·96	·12	44·91
	11	·979	210·743	209	1·779	75	33·791	205·3373	1·3169	174·06	184·56	·13	48·14	·11	45·08
	13	334·995	210·534	218	1·778	69	33·676	205·5181	1·3257	130·14	125·38	·11	48·30	·09	45·23
	15	335·013	210·316	226	+1·777	−63	33·570	205·6989	+1·3344	86·22	66·20	+0·09	48·46	·08	45·37
	17	·031	210·090	232	1·775	58	33·473	205·8797	1·3431	42·30	7·02	·08	48·60	·07	45·50
	19	·050	209·858	239	1·772	52	33·385	206·0606	1·3518	358·39	307·85	·06	48·72	·05	45·62
	21	·070	209·619	245	1·769	46	33·306	206·2415	1·3605	314·48	248·67	·05	48·84	·04	45·73
	23	·091	209·374	250	1·765	40	33·237	206·4224	1·3692	270·56	189·50	·04	48·94	·03	45·83
	25	335·113	209·124	255	+1·761	−34	33·177	206·6033	+1·3779	226·65	130·33	+0·03	49·03	·03	45·91
	27	·136	208·869	258	1·756	28	33·126	206·7843	1·3865	182·73	71·15	·02	49·11	·02	45 98
	29	·160	208·611	261	1·751	22	33·085	206·9653	1·3952	138·82	11·97	·01	49·17	·01	46·04
	31	·184	208·350	264	1·745	16	33·055	207·1463	1·4038	94·90	312·79	·01	49·21	·01	46·08
Sept.	2	·209	208·086	265	1·738	10	33·034	207·3274	1·4124	50·98	253·61	·00	49·24	·00	46·11
	4	335·235	207·821	265	+1·731	− 4	33·023	207·5085	+1·4210	7·05	194·42		49·26		46·12
	6	·261	207·556	265	1·723	+ 2	33·021	207·6896	1·4296	323·11	135·23		49·26		46·12
	8	·288	207·291	264	1·715	8	33·031	207·8708	1·4382	279·17	76·03	·00	49·25		46·11
	10	·315	207·027	262	1·706	14	33·050	208·0520	1·4468	235·22	16·82	−0·01	49·22	·00	46·09

Greenwich Noon	Angle of Position of ℳ's Axis. P	L−O.	Diff.	B	Corr. of log. Δ.	Light-time.	Δ−O.	β	Longitude of ℳ's Central Meridian. (877°·90) I.	(870°·27) II.	Corr. for Phase.	Apparent Diameter. Equat.	Phase.	Polar.
1891.	°	°		°		m	°	°	°	°		″	″	″
Sept. 12	335·343	206·765	259	+1·697	+20	33 080	208·2332	+1·4553	191·27	317·60	−0·01	49·17	0·01	46·05
14	335·371	206·506	256	+1·688	+26	33·119	208·4144	+1·4639	147·30	258·38	−0·02	49·11	·01	45·99
16	·399	206·250	252	1·679	32	33·168	208·5957	1·4724	103·33	199·15	·02	49·04	·02	45·92
18	·427	205·998	247	1·669	38	33·226	208·7770	1·4809	59·35	139·90	·03	48·96	·03	45·84
20	·454	205·751	241	1·658	44	33 295	208·9583	1·4894	15·35	80·65	·05	48·86	·04	45·75
22	·482	205·510	234	1·648	50	33·373	209·1396	1·4979	331·34	21·38	·06	48·74	·05	45·64
24	335·509	205·276	228	+1·637	+56	33·460	209·3210	+1·5064	287·32	322·10	−0·07	48·62	·06	45·52
26	·536	205·048	220	1·627	62	33·556	209·5024	1 5148	243·29	262·81	·09	48·48	·07	45·39
28	·563	204·828	211	1·616	68	33·662	209·6838	1·5233	199·25	203·51	·10	48·32	·09	45·25
30	·588	204·617	203	1·605	73	33·777	209·8653	1·5317	155·19	144·19	·12	48·16	·10	45·10
Oct. 2	·613	204·414	193	1·594	79	33·901	210·0467	1·5401	111·12	84·86	·14	47·98	·12	44·93
4	335·637	204·221	183	+1·583	+85	34·033	210·2282	+1·5485	67·03	25·51	−0·16	47·80	·13	44·75
6	·660	204·038	173	2·572	90	34·174	210·4097	1·5569	22·93	326·15	·18	47·60	·15	44·57
8	·682	203·865	161	1·561	96	34·323	210·5913	1·5653	338·81	266·77	·20	47·39	·16	44·38
10	·703	203·704	150	1·550	101	34·480	210·7729	1·5737	294·68	207·38	·22	47·18	·18	44·17
12	·723	203·554	138	1·540	106	34·644	210·9545	1·5820	250·53	147·97	·24	46·95	·19	43·96
14	335·741	203·416	125	+1·529	+112	34·816	211·1361	+1·5903	206·36	88·54	−0·26	46·72	·21	43·75
16	·758	203·291	113	1·519	117	34·995	211·3178	1·5986	162·17	29·10	·28	46·48	·23	43·52
18	·773	203·178	101	1·509	122	35·181	211·4995	1·6069	117·97	329·64	·30	46·24	·24	43·29

Greenwich Noon 1891.		Angle of Position of Ψ's Axis. P	L−O.	Diff.	B	Corr. of log. Δ.	Light-time.	Δ−O.	β	Longitude of Ψ's Central Meridian. (877°·90) I.	(870°·27) II.	Corr. for Phase.	Apparent Diameter. Equat.	Phase.	Polar.
		°	°		°		m	°	°	°	°	°	″	″	″
Oct.	20	335·787	203·077	88	+1·499	+127	35·373	211·6812	+1·6152	73·75	270·16	−0·32	45·99	0·26	43·06
	22	·799	202·989	75	1·490	131	35·571	211·8629	1·6235	29·52	210·67	·34	45·73	·27	42·82
	24	335·809	202·914	61	+1·481	+136	35·776	212·0447	+1·6317	345·27	151·16	−0·36	45·47	·29	42·57
	26	·818	202·853	48	1·472	140	35·987	212·2265	1·6400	301·01	91·64	·38	45·20	·30	42·33
	28	·825	202·805	34	1·463	145	36·202	212·4083	1·6482	256·72	32·10	·40	44·93	·31	42·07
	30	·830	202·771	21	1·455	149	36·423	212·5901	1·6564	212·42	332·54	·42	44·66	·33	41·82
Nov.	1	·833	202·750	7	1·447	153	36·649	212·7719	1·6646	168·11	272·96	·44	44·39	·34	41·56
	3	335·835	202·743	7	+1·440	+157	36·879	212·9538	+1·6728	123·77	213·37	−0·45	44·11	·35	41·30
	5	·834	202·750	21	1·433	161	37·114	213·1357	1·6809	79·42	153·76	·47	43·83	·36	41·04
	7	·832	202·771	34	1·427	164	37·353	213·3176	1·6891	35·06	94·13	·48	43·55	·37	40·78
	9	·828	202·805	48	1·421	168	37·595	213·4996	1·6972	350·68	34·49	·50	43·27	·38	40·51
	11	·822	202·853	62	1·416	171	37·840	213·6815	1·7053	306·28	334·84	·51	42·99	·38	40·25
	13	335·814	202·915	75	+1·411	+174	38·088	213·8635	+1·7134	261·87	275·17	−0·52	42·71	·39	39·99
	15	·805	202·990	88	1·406	177	38·339	214·0455	1·7215	217·44	215·48	·53	42·43	·39	39·73
	17	·794	203·078	101	1·402	180	38·592	214·2275	1·7296	173·00	155·78	·54	42·15	·40	39·47
	19	·781	203·179	114	1·399	183	38·847	214·4096	1·7376	128·54	96·06	·55	41·87	·40	39·21
	21	·766	203·293	127	1·396	185	39·104	214·5917	1·7457	84·07	36·33	·55	41·60	·40	38·85
	23	335·750	203·420	140	+1·393	+187	39·363	214·7738	+1·7537	39·58	336·59	−0·56	41·32	·40	38·69
	25	·732	203·560	152	1·391	189	39·623	214·9559	1·7617	355·08	276·83	·56	41·05	·40	38·44

Greenwich Noon	Angle of Position of ♅'s Axis. P	L−O.	Diff.	B	Corr. of log. Δ.	Light-time.	Δ−O.	β	Longitude of ♅'s Central Meridian. (877°·90) I.	(870°·27) II.	Corr. for Phase.	Apparent Diameter. Equat.	Phase.	Polar.
1891.	°	°		°		m	°	°	°	°	°	″	″	″
Nov. 27	335·713	203·712	164	+1·390	+191	39·884	215·1380	+1·7697	310·57	217·06	−0·57	040·79	0·40	38·19
29	·693	203·876	177	1·389	193	40·145	215·3202	1·7776	266·05	157 28	·57	40·52	·40	37·94
Dec. 1	·671	204·053	189	1·389	194	40·407	215·5024	1·7856	221·51	97·49	·57	40·26	·40	37·69
3	335·648	204·242	200	+1·389	+195	40·669	215·6846	+1·7935	176·96	37 68	−0·57	40·00	·40	37·45
5	·623	204·442	212	1·390	196	40·931	215·8668	1·8014	132·40	337·86	·57	39·74	·39	37·21
7	·598	204·654	223	1·391	197	41·192	216·0491	1·8093	87·83	278·03	.56	39·49	·39	36·97
9	·572	204·877	234	1·392	198	41·452	216·2314	1·8172	43·25	218·19	·56	39·24	·38	36·74
11	·544	205·111	244	1·394	198	41·712	216·4137	1·8251	358·66	158·34	·55	39·00	·38	36·51
13	335·515	205·355	255	+1·397	+198	41·970	216·5960	+1·8329	314·06	98·48	−0·55	38·76	·37	36·29
15	·486	205·610	265	1·400	198	42·227	216·7783	1·8407	269·45	38·61	·54	38·52	·36	36·07
17	·456	205·875	275	1·404	198	42·482	216·9606	1·8485	224·83	338·73	·54	38·29	·36	35·85
19	·426	206·150	285	1·408	198	42·735	217·1430	1·8563	180·20	278 84	·53	38·06	·35	35·64
21	·395	206·435	294	1·413	197	42·986	217·3254	1·8641	135·56	218·95	·52	37·84	·34	35·43
23	335·363	206·729	303	+1·418	+196	43·235	217·5079	+1·8719	90·91	159·04	−0·51	37·62	0·33	35·23
25	·331	207·032	312	1·424	195	43·482	217·6903	1·8796	46·26	99·13	·49	37·41	·32	35·03
27	·299	207·344	321	1·430	194	43·725	217·8728	1·8873	1·60	39·21	·48	37·20	·31	34·83
29	·267	207·665	330	1·436	192	43·966	218·0553	1·8950	316·93	339·28	·47	37·00	·30	34·64
31	·234	207·995	338	1·443	191	44·203	218·2378	1·9027	272·26	279·35	·46	36·80	·29	34·46

Greenwich Noon		Angle of Position of 𝔘's Axis. P	L−O.	Diff.	B	Corr. of log. Δ.	Light-time.	Δ−O.	β	Longitude of 𝔘's Central Meridian. (877°·90) I.	(870°·27) II.	Corr. for Phase.	Apparent Diameter. Equat.	Phase.	Polar.
1892.		°	°		°		m	°	°	°	°	°	″	″	″
Jan.	2	335·201	208·333	346	+1·451	+189	44·437	218·4203	+1·9103	227·58	219·41	−0·44	36·61	0·28	34·28
	4	·169	208·679	353	1·459	187	44·667	218·6028	1·9180	182·89	159·47	·43	36·42	·27	34·10
	6	·137	209·032	361	1·467	185	44·894	218·7854	1·9256	138·20	99·52	·41	36·23	·26	33·93
	8	·105	209·393	368	1·475	182	45·116	218·9679	1·9332	93·50	39·56	·40	36·05	·25	33·76
	10	·073	209·761	375	1·484	180	45·335	219·1505	1·9408	48·80	339·60	·38	35·88	·24	33·60
	12	335·041	210·136	382	+1·493	+177	45·549	219·3331	+1·9483	4·10	279·64	−0·37	35·71	·23	33·44
	14	335·010	210·518	388	1·503	175	45·759	219·5158	1·9559	319·39	219·67	·35	35·55	·22	33·29
	16	334·979	210·906	394	1·513	171	45·964	219·6984	1·9634	274·68	159·70	·34	35·39	·21	33·14
	18	·949	211·300	401	1·524	167	46·164	219·8811	1·9709	229·96	99·72	·32	35·24	·20	32·99
	20	·920	211·701	406	1·535	164	46·360	220·0638	1·9784	185·24	39·74	·30	35·09	·19	32·85
	22	334·891	212·107	411	+1·546	+160	46·550	220·2465	+1·9859	140·51	339·76	−0·29	34·94	·18	32·72
	24	·863	212·518	417	1·557	156	46·736	220·4292	1·9933	95·79	279·78	·27	34·80	·17	32·59
	26	·836	212·935	423	1·569	152	46·916	220·6119	2·0008	51·06	219·79	·26	34·67	·16	32·47
	28	·810	213·358	427	1·581	148	47·091	220·7947	2·0082	6·33	159·80	·24	34·54	·15	32·35
	30	·785	213·785	432	1·594	143	47·261	220·9774	2·0156	321·60	99·81	·23	34·42	·14	32·23
Feb.	1	334·761	214·217	436	+1·606	+139	47·424	221·1602	+2·0229	276·87	39·82	−0·21	34·30	·13	32·12
	3	·738	214·653	440	1·619	134	47·582	221·3430	2·0303	232·14	339·83	·20	34·19	·12	32·01
	5	·716	215·093	444	1·632	130	47·734	221·5259	2·0376	187·41	279·84	·18	34·08	·11	31·91
	7	·695	215·537	448	1·646	125	47·880	221·7087	2·0449	142·67	219·85	·17	33·97	·10	31·81
	9	·675	215·985	452	1·660	120	48·021	221·8916	2·0522	97·94	159·85	·15	33·87	·09	31·72
	11	334·657	216·437		+1·674	+114	48·155	222·0745	+2·0595	53·21	99·86	−0·14	33·78	0·08	31·63

The present ephemeris is intended to be of service not only for physical observations of *Jupiter*, but also in the computations of the positions of the satellites, for which the necessary data and tables will be supplied in the next number of the *Monthly Notices*. For this reason some alterations have been made, and the data are furnished for every second, instead of every fifth, day, so that the second differences may be more easily taken into account.

The angle L—O+180° is the jovicentric longitude of the Earth, reckoned in the assumed plane of *Jupiter's* equator from O, the point of the vernal equinox of *Jupiter's* northern hemisphere, or the point of the descending node of the planet's equator on its orbit. B denotes the jovicentric latitude of the Earth above *Jupiter's* equator.

"Corr. of log. Δ" is the correction to be applied to the *Nautical Almanac* "log. of true distance from the Earth" in order to obtain the log. of the distance between the Earth at Greenwich noon and the place of *Jupiter* at the time, when the light-waves arriving at Greenwich noon left the planet. These corrected distances are to be interpolated directly for the times for which the apparent positions of the satellites are to be computed in order to get the distances which ought to be employed.

The column "Light-time" gives the interval of mean time, expressed in minutes, which light requires to traverse the corrected distance. The adopted constant for distance 1 is $498^{s}\cdot92$, corresponding to the constant of aberration $20''\cdot492$.

The angle Λ—O+180° is the jovicentric apparent longitude of the Sun or Λ—O the longitude of the axis of the shadow-cone, β the latitude of the Sun above *Jupiter's* equator.

The two values of the "longitude of ♃'s central meridian" given for each date are computed with the same rates of rotation as in the ephemerides for several preceding oppositions; but in "system II." the zero-meridian has been put back 10° or the longitudes have been increased 10°, so that the great spot, in case it keeps to the adopted rate, may just follow the zero-meridian. Should the motion become more settled, the time will have arrived for the proper investigation of its fluctuations since the appearance of the spot in 1879. According to Mr. A. S. Williams's interesting observations of *Jupiter's* spots, made in 1890, and published in the *Journal of the British Astronomical Association*, vol. i. pp. 116–119, "the bright equatorial zone appeared in a remarkable state of quiescence. Conspicuous markings were hardly ever seen. . . ." The two bright spots of 1888, on the observed motions of which the daily rate 877°·90 depends (*vide M. N.* vol. xlix. pp. 88 and 94), do not seem to have been recognised under such altered conditions in 1890, but as the motions of the two markings, of which some observed transit-times are published, are approximately represented by the rate adopted in system I. of the ephemeris, I have made no alteration. It is to be hoped that during the ensuing more

favourable apparition of *Jupiter* the surface of the planet will be assiduously scrutinised, and the times of transits of all the more remarkable spots and markings across the middle of the disc carefully recorded.

The differences of successive values of the longitudes of ♃'s central meridian vary for I. between 1755°·28 and 1756°·08, and for II. between 1740°·02 and 1740°·82.

The addition of the "correction for phase" to the longitudes of the central meridian gives the longitudes of the meridian which bisects the illuminated disc. The following is a list of Greenwich mean times, when the zero-meridian in the assumed two systems of longitudes will pass the middle of the disc. The times between successive passages vary between $10^h\ 50^m{\cdot}40$ and $50^m{\cdot}68$ in the first system, and between $10^h\ 55^m{\cdot}58$ and $55^m{\cdot}86$ in the second.

1891.	I. (877°·90) h m	II. (870°·27) h m	1891.	I. (877°·90) h m	II. (870°·27) h m
Apr. 17	13 44·6	18 57·0	May 10	12 56·6	13 3·1
18	19 16·4	14 48·5		22 47·1	22 58·9
19	14 57·6	20 35·8	11	8 37·7	8 54·6
20	20 29·3	16 27·3		18 28·2	18 50·3
21	16 10·5	12 18·8	12	14 9·3	14 41·8
22	11 51·6	18 6·1	13	9 50·4	10 33·3
23	17 23·4	13 57·6		19 41·0	20 29·0
24	13 4·5	19 44·9	14	15 22·1	16 20·4
25	18 36·3	15 36·4	15	11 3·2	12 11·9
26	14 17·4	11 27·9		20 53·7	22 7·6
27	9 58·6	7 19·4	16	6 44·3	8 3·3
	19 49·2	17 15·2		16 34·8	17 59·0
28	15 30·3	13 6·7	17	12 15·9	13 50·5
29	11 11·4	8 58·2		22 6·4	23 46·2
	21 2·0	18 53·9	18	7 57·0	9 41·9
30	16 43·1	14 45·4		17 47·5	19 37·6
May 1	12 24·3	10 36·9	19	13 28·6	5 33·3
	22 14·8	20 32·6		23 19·1	15 29·1
2	8 5·4	6 28·4	20	9 9·7	11 20·5
	17 56·0	16 24·1		19 0·2	21 16·2
3	13 37·1	12 15·6	21	14 41·3	17 7·6
	23 27·8	22 11·4	22	10 12·5	12 59·1
4	9 18·3	8 7·1		20 12·9	22 54·8
	19 8·8	18 2·8	23	6 3·4	8 50·5
5	14 49·9	13 54·3		15 53·9	18 46·2
6	10 31·0	9 45·8	24	11 35·0	14 37·6
	20 21·6	19 41·5		21 25·5	24 33·3
7	16 2·7	15 33·0	25	7 16·1	10 29·0
8	11 43·8	11 24·5		17 6·6	20 24·8
	21 34·4	21 20·2	26	12 47·7	6 20·5
9	7 24·9	7 15·9		22 38·2	16 16·2
	17 15·5	17 11·7	27	8 28·7	12 7·6

1891.	I. (877°·90) h m	II. (870°·27) h m
May 27	18 19·2	22 3·3
28	14 0·3	7 59·0
	23 50·8	17 54·7
29	9 41·3	13 46·1
	19 31·9	23 41·8
30	5 22·4	9 37·5
	15 12·9	19 33·2
31	10 53·9	15 24·6
	20 44·5	25 20·3
June 1	6 35·0	11 16·0
	16 25·5	21 11·7
2	12 6·5	7 7·4
	21 57·0	17 3·1
3	7 47·6	12 54·5
	17 38·1	22 50·1
4	13 19·1	8 45·8
	23 9·6	18 41·5
5	9 0·1	14 32·9
	18 50·6	24 28·6
6	14 31·7	10 24·3
	24 22·2	20 20·0
7	10 12·7	6 15·7
	20 3·2	16 11·4
8	15 44·2	12 2·7
	25 34·7	21 58·4
9	11 25·2	7 54·1
	21 15·7	17 49·8
10	7 6·2	13 41 1
	16 56·7	23 36·8
11	12 37·7	9 32·5
	22 28·2	19 28·2
12	8 18·7	15 19·5
	18 9·2	25 15·2
13	13 50·2	11 10·9
	23 40·7	21 6·6
14	9 31·2	7 2·2
	19 21·7	16 57·9
15	15 2·7	12 49·2
	24 53·2	22 44·9
16	10 43·7	8 40·6
	20 34·2	18 36·3
17	6 24·7	14 27·6
	16 15·2	24 23·3
18	11 56·1	10 18·9
	21 46·6	20 14·6

1891.	I. (877°·90) h m	II. (870°·27) h m
June 19	7 37·1	6 10·3
	17 27·6	16 5·9
20	13 8·6	11 57·2
	22 59·1	21 52·9
21	8 49·5	7 48·6
	18 40·0	17 44·2
22	14 21·0	13 35·5
	24 11·5	23 31·2
23	10 2·0	9 26·9
	19 52·5	19 22·5
24	15 33·4	15 13·8
25	1 23·9	1 9·5
	11 14·4	11 5·2
	21 4·9	21 0·8
26	6 55·3	6 56·5
	16 45·8	16 52·1
27	12 26·8	12 43·4
	22 17·2	22 39·1
28	8 7·7	8 34·7
	17 58·2	18 30·4
29	13 39·1	14 21·7
	23 29·6	24 17·3
30	9 20·0	10 13·0
	19 10·5	20 8·6
July 1	14 51·4	15 59·9
2	0 41·9	1 55·6
	10 32·4	11 51·2
	20 22·9	21 46·8
3	6 13·3	7 42·5
	16 3·8	17 38·1
4	11 45·7	13 29·4
	21 35·2	23 25·0
5	7 25·6	9 20·7
	17 16·1	19 16·3
6	12 57·0	15 7·6
	22 47·5	25 3·2
7	8 37·9	10 58·9
	18 28·4	20 54·5
8	14 9·3	6 50·1
	23 59·8	16 45·8
9	9 50·2	12 37·0
	19 40·7	22 32·7
10	5 31·1	8 28·3
	15 21·6	18 23·9
11	11 2·5	14 15·2

1891.	I. (877°·90) h m	II. (870°·27) h m
July 11	20 52·9	24 10·8
12	6 43·4	10 6·4
	16 33·8	20 2·1
13	12 14·7	5 57·7
	22 5·2	15 53·3
14	7 55·6	11 44·6
	17 46·1	21 40·2
15	13 27·0	7 35·8
	23 17·4	17 31·4
16	9 7·9	13 22·7
	18 58·3	23 18·3
17	14 39·2	9 13·9
	24 29·6	19 9·5
18	10 20·1	15 0·8
	20 10·5	24 56·4
19	6 1·0	10 52·0
	15 51·4	20 47·6
20	11 32·3	6 43·2
	21 22·7	16 38·9
21	7 13·2	12 30·1
	17 3·6	22 25·7
22	12 44·5	8 21·3
	22 34·9	18 16·9
23	8 25·3	14 8·1
	18 15·8	24 3·7
24	13 56·6	9 59·4
	23 47·1	19 55·0
25	9 37·5	5 50·6
	19 27·9	15 46·2
26	15 8·8	11 37·4
	24 59·2	21 33·0
27	10 49·6	7 28·6
	20 40·1	17 24·2
28	6 30·5	13 15·4
	16 20·9	23 11·0
29	12 1·8	9 6·6
	21 52·2	19 2·2
30	7 42·6	14 53·4
	17 33·0	24 49·0
31	13 13·9	10 44·6
	23 4·3	20 40·2
Aug. 1	8 54·7	6 35·8
	18 45·2	16 31·4
2	14 26·0	12 22·6
	24 16·4	22 18·2

1891.	I. (877°·90) h m	II. (870°·27) h m
Aug. 3	10 6·8	8 13·8
	19 57·3	18 9·4
4	5 47·7	14 0·6
	15 38·1	23 56·2
5	11 18·9	9 51·8
	21 9·4	19 47·4
6	6 59·8	5 42·9
	16 50·2	15 38·5
7	12 31·0	11 29·7
	22 21·4	21 25·3
8	8 11·8	7 20·9
	18 2·3	17 16·5
9	13 43·1	13 7·7
	23 33·5	23 3·3
10	9 23·9	8 58·9
	19 14·3	18 54·4
11	14 55·2	14 45·6
12	0 45·6	0 41·2
	10 36·0	10 36·8
	20 26·4	20 32·4
13	6 16·8	6 28·0
	16 7·2	16 23·6
14	11 48·1	12 14·7
	21 38·5	22 10·3
15	7 28·9	8 5·9
	17 19·3	18 1·5
16	13 0·1	13 52·7
	22 50·5	23 48·3
17	8 40·9	9 43·8
	18 31·3	19 39·4
18	14 2·1	15 30·6
19	0 2·5	1 26·2
	9 52·9	11 21·8
	19 43·4	21 17·3
20	5 33·8	7 12·9
	15 24·2	17 8·5
21	11 5·0	12 59·7
	20 55·4	22 55·3
22	6 45·8	8 50·8
	16 36·2	18 46·4
23	12 17·0	14 37·6
	22 7·4	24 33·2
24	7 57·8	10 28·8
	17 48·3	20 24·3
25	13 29·1	6 19·9

1891.	I. (877°·90) h m	II. (870°·27) h m
Aug. 25	23 19·5	16 15·5
26	9 9·9	12 6·7
	19 0·3	22 2·2
27	4 50·7	7 57·8
	14 41·1	17 53·4
28	10 21·9	13 44·6
	20 12·3	23 40·2
29	5 2·7	9 35·7
	15 53·1	19 31·3
30	11 33·9	5 26·9
	21 24·3	15 22·5
31	7 14·7	11 13·7
	17 5·2	21 9·2
Sept. 1	12 46·0	7 4·8
	22 36·4	17 0·4
2	8 26·8	12 51·6
	18 17·2	22 47·2
3	4 7·6	8 42·8
	13 58·0	18 38·3
4	9 38·8	4 33·9
	19 29·3	14 29·5
5	5 19·7	10 20·7
	15 10·1	20 16·3
6	10 50·9	6 11·9
	20 41·3	16 7·5
7	6 31·7	11 58·6
	16 22·1	21 54·2
8	12 3·0	7 49·8
	21 53·4	17 45·4
9	7 43·8	3 41·0
	17 34·2	13 36 6
10	13 15·1	9 27·8
	23 5·5	19 23·4
11	8 55·9	5 19·0
	18 46·3	15 14·6
12	4 36·7	11 5·8
	14 27·2	21 1·4
13	10 8·0	6 56·9
	19 58·4	16 52·5
14	5 48·8	2 48·1
	15 39·3	12 43·7
15	11 20·1	8 35·0
	21 10·6	18 30·6
16	7 1·0	4 26·2
	16 51·4	14 21·8

1891.	I. (877°·90) h m	II. (870°·27) h m
Sept. 17	2 41·9	10 13·0
	12 32·3	20 8·6
18	8 13·2	6 4·2
	18 3·6	15 59·8
19	3 54·0	1 55·4
	13 44·5	11 51·0
20	9 25·3	7 42·3
	19 15·8	17 37·9
21	5 6·2	3 33·5
	14 56·7	13 29·1
22	10 37·5	9 20·3
	20 28·0	19 16·0
23	6 18·4	5 11·6
	16 8·9	15 7·2
24	1 59·3	1 2·8
	11 49·7	10 58·4
25	7 30·6	6 49·7
	17 21·1	16 45·3
26	3 11·5	2 40·9
	13 2·0	12 36·6
27	8 42·9	8 27·8
	18 33·4	18 23·5
28	4 23·8	4 19·1
	14 14·3	14 14·7
29	9 55·2	10 6·0
	19 45·6	20 1·6
30	5 36·1	5 57·3
	15 26·6	15 52·9
Oct. 1	1 17·0	1 48·5
	11 7·5	11 44·2
2	6 48·4	7 35·5
	16 38·9	17 31·1
3	2 39·4	3 26·8
	12 19·8	13 22·4
4	8 0·8	9 13·7
	17 51·2	19 9·4
5	3 41·7	5 5·0
	13 32·2	15 0·7
6	9 13·2	0 56·3
	19 3·6	10 52·0
7	4 54·1	6 43·3
	14 44·6	16 38·9
8	0 35·1	2 34·6
	10 25·6	12 30·2
9	6 6·5	8 21·6

1891.	I. (877°·90) h m	II. (870°·27) h m
Oct. 9	15 57·0	18 17·2
10	1 47·5	4 12·9
	11 38·0	14 8·5
11	7 19·0	9 59·9
	17 9·5	19 55·6
12	3 0·0	5 51·2
	12 50·4	15 46·9
13	8 31·4	1 42·6
	18 21·9	11 38·2
14	4 12·4	7 29·6
	14 2·9	17 25·3
15	9 43·9	3 21·0
	19 34·4	13 16·6
16	5 14·9	9 8·0
	15 5·5	19 3·7
17	0 56·0	4 59·4
	10 46·5	14 55·0
18	6 37·5	0 50·7
	16 28·0	10 46·4
19	2 18·5	6 37·8
	12 9·0	16 33·5
20	7 50·1	2 29·2
	17 40·6	12 24·9
21	3 31·1	8 16·3
	13 21·6	18 12·0
22	9 2·7	4 7·7
	18 53·2	14 3·4
23	4 43·7	9 54·8
	14 34·2	19 50·5
24	0 24·8	5 46·2
	10 15·3	15 41·9
25	5 56·3	1 37·6
	15 46·9	11 33·3
26	1 37·4	7 24·7
	11 27·9	17 20·4
27	7 9·0	3 16·1
	16 59·5	13 11·8
28	2 50·1	9 3·3
	12 40·6	18 59·0
29	8 21·7	4 54·7
	18 12·2	14 50·4
30	4 2·8	0 46·1
	13 53·3	10 41·9
31	9 34·4	6 33·3
	19 24·9	16 29·0
Nov. 1	5 15·5	2 24·7

1891.	I. (877°·90) h m	II. (870°·27) h m
Nov. 1	15 6·0	12 20·5
2	0 56·6	8 11·9
	10 47·1	18 7·7
3	6 28·3	4 3·4
	16 18·8	13 59·1
4	2 9·4	9 50·6
	11 59·9	19 46·3
5	7 41·0	5 42·1
	17 31·6	15 37·8
6	3 22·2	1 33·5
	13 12·7	11 29·3
7	8 53·8	7 20·8
	18 44·4	17 16·5
8	4 35·0	3 12·2
	14 25·5	13 8·0
9	0 16·1	8 59·5
	10 7·7	18 55·2
10	5 47·8	4 51·0
	15 38·4	14 46·7
11	1 29·0	0 42·5
	11 19·5	10 38·2
12	7 0·7	6 29·7
	16 51·2	16 25·5
13	2 41·8	2 21·2
	12 32·4	12 17·0
14	8 13·6	8 8·5
	18 4·1	18 4·3
15	3 54·7	4 0·0
	13 45·3	13 55·8
	23 35·9	23 51·3
16	9 26·5	9 47·3
17	5 7·7	5 38·9
	14 58·2	15 34·6
18	0 48·8	1 30·4
	10 39·4	11 26·2
19	6 20·6	7 17·7
	16 11·2	17 13·5
20	2 1·8	3 9·2
	11 52·4	13 5·0
21	7 33·6	8 56·6
	17 24·2	18 52·3
22	3 14·8	4 48·1
	13 5·4	14 43·9
23	8 46·6	0 39·7
	18 37·2	10 35·4
24	4 27·8	6 27·0

	I. (877°·90)	II. (870°·27)
1891.	h m	h m
Nov. 24	14 18·4	16 22·8
25	0 9·0	2 18·6
	9 59·6	12 14·3
26	5 40·8	8 5·9
	15 31·4	18 1·7
27	1 22·0	3 57·5
	11 12·6	13 53·3
	21 3·2	23 49·1
28	6 53·8	9 44·9
29	2 35·1	5 36·4
	12 25·7	15 32·2
	22 16·3	25 28·0
30	8 6·9	11 23·8
Dec. 1	3 48·1	7 15·4
	13 38·7	17 11·2
2	9 20·0	3 7·0
3	5 1·2	8 54·4
4	0 42·5	4 46·0
	10 33·1	14 41·8
5	6 14·3	0 37·6
	16 4·9	10 33·4
6	1 55·6	6 25·0
	11 46·2	16 20·8
7	7 27·4	2 16·6
	17 18·1	12 12·4
8	3 8·7	8 4·0
	12 59·3	17 59·8
9	8 40·6	3 55·6
	18 31·2	13 51·4
10	4 21·8	9 43·0
11	0 3·1	5 34·7
	9 53·7	15 30·5
12	5 35·0	1 26·3
	15 25·6	11 22·1
13	1 16·3	7 13·7
	11 6·9	17 9·5
14	6 48·2	3 5·4
	16 38·8	13 1·2
15	2 29·4	8 52·8
16	8 1·4	4 44·4
17	3 42·6	0 36·1
	13 33·3	10 31·9
18	9 14·6	6 23·5
19	4 55·9	2 15·2
	14 46·5	12 11·0
	24 37·1	22 6·8

	I. (877°·90)	II. (870°·27)
1891.	h m	h m
Dec. 20	10 27·8	8 2·7
21	6 9·1	3 54·3
	25 50·4	23 46·0
22	11 41·0	9 41·8
23	7 32·2	5 33·4
24	3 3·6	1 25·1
	12 54·3	11 20·9
25	8 35·6	7 12·6
26	4 16·9	3 4·2
	23 58·2	22 55·9
27	9 48·8	8 51·7
28	5 30·1	4 43·4
29	1 11·4	0 35·1
	11 2·1	10 30·9
30	6 43·4	6 22·6
31	2 24·7	2 14·2
	12 15·4	12 10·1
	22 6·0	22 5·9
1892.		
Jan. 1	7 56·7	8 1·7
2	3 38·0	3 53·4
	23 19·3	23 45·1
3	9 10·0	9 40·9
4	4 51·3	5 32·6
5	0 32·6	1 24·3
	10 23·3	11 20·1
6	6 4·6	7 11·8
7	1 45·9	3 3·5
	11 36·6	12 59·3
	21 27·2	22 55·2
8	7 18·9	8 51·0
9	2 59·2	4 42·7
	12 49·9	14 38·6
	22 40·6	24 34·4
10	8 31·2	10 30·2
11	4 12·5	6 21·9
	23 53·9	26 13·6
12	9 44·5	12 9·5
13	5 25·9	8 1·2
14	1 7·2	3 52·8
	10 57·9	23 44·5
15	6 39·2	9 40·4
16	2 20·5	5 32·1
	22 1·9	25 23·8
17	7 52·5	11 19·6
18	3 33·9	7 11·3

	I. (877°·90)	II. (870°·27)		I. (877°·90)	II. (870°·27)
1892.	h m	h m	1892.	h m	h m
Jan. 18	23 15·2	17 7·2	Jan. 29	5 22·0	1 23·5
19	9 5·9	3 3·0	30	1 3·4	7 11·0
20	4 47·2	8 50·6	31	6 35·4	3 2·7
21	0 28·6	4 42·3	Feb. 1	2 16·7	8 50·3
22	6 0·6	0 34·0	2	7 48·8	4 42·0
23	1 41·9	6 21·5	3	3 30·1	0 33·7
24	7 15·0	2 13·2		23 11·5	20 25·4
25	2 55·3	8 0·8	4	9 2·1	6 21·3
26	8 27·3	3 52·5	5	4 43·5	2 13·0
27	4 8·7	9 40·0		14 34·1	22 4·7
28	9 40·7	5 29·8	6	0 24·8	8 0·5

Errata in Mr. Turner's Note on the Recent Determination of the Longitude of Paris, Vol. LI. No. 3.

Page 156, line 2, *for* 44 13·75 *read* 44 13·86
„ „ 3, *for* 9 21·16 *read* 9 21·05
„ „ 12, *for* 19 2·12 *read* 19 2·23
„ „ 13, *for* 9 21·19 *read* 9 21·08

[I am indebted to Professor Th. Albrecht for calling my attention to the note on p. 131 of *Astr. Nachr.* No. 2265, which indicates the necessity of these changes. An erroneous correction to the meridian of France was applied in forming the results published under the references given in my paper. The diagram on p. 156 should, of course, be altered accordingly.]

Page 163, footnote, second line, *for* 12 feet, or 0ˢ·01, *read* 20 feet, or 0ˢ·02.

[The numbers given in the text are correct, but a final correction was not extended to the footnote.]